

**A GROUND PENETRATING RADAR REFERENCE GUIDE OF  
FIVE HISTORIC SITES**

**A THESIS  
SUBMITTED TO THE GRADUATE SCHOOL  
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
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**BY  
AMANDA BALOUGH  
MARK D. GROOVER, CHAIR  
BALL STATE UNIVERSITY  
MUNCIE, IN**

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## **Abstract**

In recent years, ground-penetrating radar (GPR) has become more widely used by archaeologists to map subsurface features at archaeological sites. The radar allows for quick survey of a landscape without disturbing subsurface features and helps preserve the archaeological record. The signal can be blocked or distributed based upon the soil composition, such as glacial till and soil saturation. There are very few reference texts to assist those learning how to identify GPR features at a variety of sites. To help fill in this gap in the Midwest, this thesis project proposes to create a catalog of GPR features from a variety of historic sites, which can be used as a reference guide for beginners studying GPR methods and GPR anomaly identification. As this research developed, this thesis project shifted from creating a catalog into creating a reference guide for future use.

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# **Chapter I: Introduction**

## **Purpose**

In the field of geophysics and archaeology, ground penetrating radar (GPR) has been used on many archaeological sites to better assist with site excavation, interpretation, and preservation. To be able to apply ground penetrating radar, the archaeologist must have the ability to effectively operate the equipment and they must be familiar with the technical knowledge to analyze and interpret the survey results. The data analysis and interpretation process is the most challenging and intimidating process to beginners studying GPR. A review of available manuals and journals presenting GPR analysis of archaeological sites showed that only a few researchers describe and outline their analysis, interpretation, and identification process.

The purpose of this thesis is to create a catalog for GPR interpretation and anomaly identification that illustrates the whole process. This catalog will be accessible for other beginners who are starting their education with GPR. It consists of GPR data from a variety of site types, providing a diversity of GPR anomalies for interpretation. As originally planned, the catalog was to contain data from ten historic sites, but the number of sites was subject to change based upon time constrictions and site availability. Data was gathered from nine sites: Fort Recovery Ohio, Great Saltpetre Cave Kentucky, Knights of Columbus McGowan Hall in Indianapolis Indiana, the Minnetrista Historical Complex Orphans' Home Indiana, Moore-Youse historical house in Muncie Indiana, the Mount Saint Pleasant Cemetery in Dearborn County Indiana, Thomas Neely House in Muncie Indiana, the Eaton House which is a residential home in Eaton Indiana, and the Nottingham Cemetery in Delaware County, Indiana. Permission was granted for all sites to be surveyed (Appendix A: Permission Form). As the project progressed, the catalog developed into more of a reference guide because the sample of sites in each category

(e.g., cemetery) was not enough to represent the range of variability for each type of site.

Another limitation is that the author currently lacks the data gathering skills and interpretation knowledge to create a reliable catalog. To facilitate completion of the project, the number of sites to be analyzed was reduced to five, per the author's selection. The five selected sites include: Moore-Youse House Museum in Muncie, the Nottingham Cemetery in Muncie, the Minnetrista Historical Complex Orphans' Home in Muncie, the Indianapolis Knights of Columbus McGowan Hall in Indianapolis, and a local residential septic tank survey in Eaton.

The surveys revealed subsurface features present within the survey grids. Ground penetrating radar spatially displays those features and enables the researcher to recreate the landscape history of the site from occupation to the present time. Modernization theory was then applied to analyze all anomalies, including modern features. Most researchers disregard modern features, but this is a disservice to the site since it leaves the site landscape history incomplete.

After all sites were analyzed, this study arrived at three important conclusions. First, the strengths and weaknesses of GPR in archaeological settings were examined and revealed. Second, this research shows how GPR can be utilized to reveal the historic development of each site. And third, the GPR data allowed for the examination of the utility/validity of archival sources in the recreation of site structure. The experiences and knowledge gained from this thesis project provide great academic and professional development, while gathering archaeological data that can be used for future research projects.



## **Chapter Sections**

Chapter 1 provides an introduction to the thesis project, including its organization and how the original purpose evolved throughout the project. Chapter 2 presents the literature review and is divided into four sections. The first section provides an overview of what geophysics is, including the different types of geophysical equipment applied by archaeologists. Special attention is given to ground penetrating radar (GPR) and its history. The second section discusses the theories applied, providing background on the theories, the modern development, and how those theories will be applied to this thesis project. The third section of Chapter 2 discusses the geological formation of Indiana, the bedrock of Indiana, glaciation episodes, and soil regions. The final section of Chapter 2 provides case studies of geophysical surveys that have been conducted in Indiana. The case studies provide information from two cemeteries, two domestic sites, and two specialty sites.

Chapter 3 covers application and methodology. It is divided into seven sections: site selection, locality, survey preparation, grid preparation, grid setup, and data processing. The site selection section discusses the reasoning for site selection, such as locality, potential for future research, and reasoning for reducing the number of sites from ten to five. The third section of Chapter 3, survey preparation, discusses the process of preparing for site visitation and data collection. The field survey section outlines the steps and processes utilized in the field for data collection. The final section in Chapter 3, data processing, discusses how the raw data is taken from the field and processed using the RADAN processing software.

Chapter 4 presents the results from all five sites. Each site will be discussed in five parts: historic context, soil context, previous archaeological work, GPR survey, and results. Chapter 4 also provides the discussion of the survey results and presents which survey areas the GPR was

most effective in detecting anomalies related to the site, such as the McGowan Hall foundational remains and the graves from the Nottingham cemetery.

Chapter 5 presents the three findings from the thesis project, which include: the strengths and weaknesses of GPR in archaeological settings, how historic site structural development is revealed by GPR for a site over time, and how GPR is a way to ground-truth the validity of primary sources when applied for site re-creation. Chapter 5 also includes the conclusion of this thesis and a discussion of future work.

## **Chapter 2: Literature Review**

Chapter 2 is divided into four sections: geophysical methods, theory, Indiana's topographic history, and state reported surveys. The geophysical methods section provides an overview of five geophysical methods and discusses their application and benefits. This section illustrates the methods available for usage and the important criteria to consider when selecting which will be the most useful for survey. Since this thesis applies GPR, the geophysical methods section concludes with a brief history of GPR. The second section of Chapter 2 presents the theoretical ideologies that were applied to help guide this thesis. Landscape theory and modernization theory were the main theoretical perspectives applied, both to help guide the surveys and the analysis of the results. Settler colonialism was applied to frame the findings from the sites. The third section, Indiana's topographic history, provides a brief sketch of Indiana's natural history and how it might impact the GPR results. The final section of Chapter 2 reviews previous geophysical surveys conducted in the state of Indiana. The purpose of this section is to review a sample of the geophysical work in Indiana, analyze what methodology other researchers are applying in anomaly identification, and then determine what techniques to use in the data analysis of the anomalies located for this thesis.

### **Geophysical Methods**

What is geophysics and what can it do? How can it be applied to archaeological surveys and what can it accomplish that traditional archaeological methods cannot? According to the Environmental and Engineering Geophysical Society (EEGS)(2016), there are two definitions for geophysics. First, it is:

(1) The subsurface site characterization of the geology, geological structure, groundwater, contamination, and human artifacts beneath the Earth's surface, (2) based on the lateral and vertical mapping of physical property variations that are remotely sensed using non-invasive technologies. Many of these technologies are traditionally used for exploration of economic materials such as groundwater, metals, and hydrocarbons.

The second definition provided is more concise and involves the non-invasive investigation of subsurface characteristics through the measurement, analysis, and interpretation of physical fields. Some investigations target features within the upper meter of ground surface, while other investigations can extend up to ten meters or more in depth (EEGS 2016). The common theme that both definitions have is that every geophysical survey is non-invasive in technique (i.e. excavation or ground disturbance is not required). Additionally, the surveys have a specific interest for investigation (i.e. key targets) and underscore near sub-surface characteristics.

Geophysical methods of investigation have multiple benefits, including but not limited to: non-destructive, efficient, comprehensive, and cost-effective (EEGS 2016). As mentioned above, geophysical surveys do not require excavation of the ground. This preserves sub-surface features and is ideal for urban areas, when construction crews need to know the location of pipes, electrical lines, and telecommunication lines. Geophysical methods are efficient in that they provide a way to evaluate large survey areas rapidly. A combination of methods can help provide less ambiguous interpretations. Geophysical methods are cost effective because they do not require excavation, they help minimize future excavation, and they can provide detailed information about subsurface features.

While the subject of this thesis is limited to data sets gathered with a GPR unit, there are other geophysical methods, such as electrical resistivity, electromagnetic conductivity, magnetometry, and metal detection which can be used to evaluate an archaeological site (Dolphin 2011; Johnson 2006).

### **Electrical Resistivity**

Electrical resistivity survey is an active survey method and is similar to GPR in that both methods inject electromagnetic energy into the ground and record the response (Somers 2006:109). Resistivity surveys use a probe array (Figure 1 and Figure 2), which is connected to a resistance meter, to inject an electrical current into the ground and measure the subsurface resistance (Somers 2006:109). The electrical current maps areas with high electrical resistance and/or low electrical resistance in comparison to the surrounding soils (Cheetham 2008:570). Nearly all arrays rely on four electrodes to take measurements—two two for applying current and two for recording voltage. The four electrodes can be arranged in several different ways to achieve different detection depths and sensitivity. The simplest array is the Wenner array, which has four electrodes spaced equidistant from each other and the outer two electrodes are for injecting the current (Herman 2001:946). The Schlumberger array is similar to the Wenner but the spacing of the outer current electrodes is wider than the spacing of the inner voltage electrodes. A third array is the dipole–dipole arrangement. It uses pairs (current pair and voltage pair) of closely spaced electrodes, which do not have to be in line with one another (Herman 2001:947).

Electrical resistivity can be used to locate deep features, such as underground caves, foundations, and rock formations. Depth is calculated as half the distance between the outer

electrodes (Herman 2001: 945). New developments in the technology have allowed the equipment to be mounted on vehicles, allowing for rapid survey of large areas.

### **Electromagnetic Conductivity**

Electromagnetic (EM) conductivity measures the ground's ability to conduct electricity (Figure 3). EM instruments have two coils, one that transmits an electromagnetic field and a second that measures the ground's response by detecting secondary electromagnetic fields (Cheetham 2008:572). The first coil creates an electric current of known frequency and magnitude which is then induced into the ground. "The eddy currents generated in the ground in turn induce a secondary current in underground conductors which results in alternating secondary magnetic field, that is sensed by the receiving coil" (Subsurface Surveys Inc. & Associates 2007). The secondary field generated from the ground is then distinguished from the original field by the phase lag, or the different measurement between the two currents (Subsurface Surveys Inc. & Associates 2007). Values are measured in *siemens* and the results are the reciprocal of resistivity, displayed in Figure 4 (Bevan 1983:51). While the signal frequency may vary per instrument, it is critical that there is no electrical connection between the equipment and the ground (Clay 2008:4).



Figure 1: Amanda Balough assists with Electrical Resistivity Survey in Great Salt Petre Cave, Kentucky (Photo courtesy of Amber Yuellig 2016).



Figure 2: Geoscan RM15 Resistance Meter (Photo courtesy of Amanda Balough 2017).





Figure 3: An EM38 Survey Instrument (Photo courtesy of Amanda Balough 2017).

<u>Soil</u>	<u>Resistivity ohm-m</u>	<u>Conductivity mS/m</u>
Sand, gravel	1000 – 10,000	0.1 – 1
Silty sand	200 – 1000	1 – 5
Loam	80 – 200	5 – 25
Silt	40 – 80	12.5 – 25
Clay	10 – 40	25 – 100
Saline soil	5 – 10	100 – 200

Figure 4: Resistivity Measurements for Soils (Bevan 1983).



## **Magnetometry**

Magnetometry was originally developed to detect geological structures which contained economically valuable minerals or other resources (Aitkin 1958). This technique, like many other geophysical methods, has been modified for many applications and is one of the primary instrument types used in archaeology (Figure 5). Magnetometry can be used to survey large areas quickly. These are several different types of magnetometers, including those with fluxgate, cesium, proton precession and superconducting quantum interference device (SQUID) sensors (Kvamme 2006; Schultze et al 2005). Magnetometry maps variations of the earth's magnetic field close to the surface. It is a passive survey method because it uses the earth's magnetic field, rather than creating its own artificial field (Kvamme 2006:206). The causes for the variation of features can be due to a range of circumstances, but more often than not the causes are due to burning (Cheetham 2008:568). Burning contributes to the magnetic enhancement of deposits and allows archaeologists to map agricultural fields, pits, silos, hearths, and ovens (Cheetham 2008:568). It can also help to identify organized higher-intensity production activities, including, for example, salt production, ceramic production, and metallurgy (Cheetham 2008:568).



Figure 5: Barington Two Coil Gradiometer (Photo courtesy of Amanda Balough 2017).

## **Metal Detection**

Metal detection has become the most accessible geophysical method for archaeologists and enthusiasts. Metal detectors are smaller, more simplistic versions of the conductivity meter and they are designed to react to the electrical conductivity of subsurface objects (Connor and Scott 1998). All metal detectors are designed with a handle, search coil, cable, and control box for the battery and tuning apparatus, seen in Figure 6 (Connor and Scott 1998). When objects of metallic characteristics are in proximity to the coil, the metal detector indicates the object by displaying it visually and/or audibly. The electromagnetic field, which creates a conical shaped signal with circular coils, can be larger or smaller based upon the coil size (Connor and Scott 1998). The coil is swung over the ground surface in a back-and-forth motion while overlapping to get accurate indications of object location (Connor and Scott 1998). Smaller coils are more precise for detecting objects at shallow depths, while the larger coils have the ability to reach deeper (Connor and Scott 1998).

## **Ground Penetrating Radar**

Ground penetrating radar (GPR) is an active technique that uses radio waves to identify archaeological features below ground (Figure 7). Radar systems transmit pulses of radio waves, in select frequency ranges, and then record any reflections that come back to the instrument. When radar energy crosses over subsurface materials with different properties (e.g., chemical, physical), the velocity of the radar waves changes and some of the radar energy is reflected back up towards the surface (Dam et al. 2002). Normally, the amount of energy return is related to variation in retained or distributed water, which will affect velocity and can be directly related to physical properties of subsurface features (Calia et al. 2012; Conyers 2004a; Conyers 2012:34).

Other environmental factors which can affect radar propagation and reflection are electrical conductivity, which is related to the amount of retained water in the ground, and magnetic permeability (Dam and Schlager 2000; Olhoeft 1981; Reynolds 2011;). If the factors that affect radar wave propagation are known (which is rarely the case), then the amount reflection at a subsurface feature and the depth of the energy penetration can usually be predicted. However, there are other methods that can be used to determine depth.

Relative dielectric permittivity (RDP), is a measure of a material's ability to store a charge and then transmit the energy (ASTM International 2003; Von Hippel 1954; Wensink 1993). It is one of the primary factors influencing radar wave propagation and reflection, and is necessary for understanding the results of radar surveys. Normally, the greater the RDP of the subsurface material, the slower the radar energy will move through the feature. "Relative dielectric permittivity is a general measurement of how well radar energy will be transmitted to depth. It therefore measures the velocity of propagating radar energy and also its strength" (Conyers 2013:49). RDP and velocity can be interchanged to determine the velocity of propagation in the ground. For example, fresh water has a very high RDP of about 80 and radar energy can be transmitted without it being lessened (Figure 8). Ice is a good medium for radar energy, which is why the earliest application of GPR was on glaciers (Arcone 1996; Arcone and Kreutz 2009). Knowledge of soil composition allows the researcher to take into consideration how fast the radar energy will travel though the ground and make calibration adjustments. Figure 8 presents the typical RDP range of common geological materials.





Figure 6: Metal Detection at Springhead, England (Wessex Archaeology Online 2008).



Figure 7: GSSI SIR-3000 GPR Survey by Ball State Students at Great Salt Petre Cave, Kentucky (Photo courtesy of Amber Yuellig 2017).

Material	Dielectric Constant	Material	Dielectric Constant
Air	1	Wet Sandstone	6
Snow Firn	1.5	Wet Granite	6.5
Dry Loamy/Clayey Soils	2.5	Travertine	8
Dry Clay	4	Wet Limestone	8
Dry Sands	4	Wet Basalt	8.5
Ice	4	Tills	11
Coal	4.5	Wet Concrete	12.5
Asphalt	5	Volcanic Ash	13
Dry Granite	5	Wet Sands	15
Frozen Sand & Gravel	5	Wet Sandy Soils	23.5
Dry Concrete	5.5	Dry Bauxite	25
Dry Limestone	5.5	Saturated Sands	25
Dry Sand & Gravel	5.5	Wet Clay	27
Potash Ore	5.5	Peats (saturated)	61.5
Dry Mineral/Sandy Soils	6	Organic Soils (saturated)	64
Dry Salt	6	Sea Water	81
Frozen Soil/Permafrost	6	Water	81
Syenite Porphyry	6		

Figure 8: Material Dielectrics (GSSI 2016).

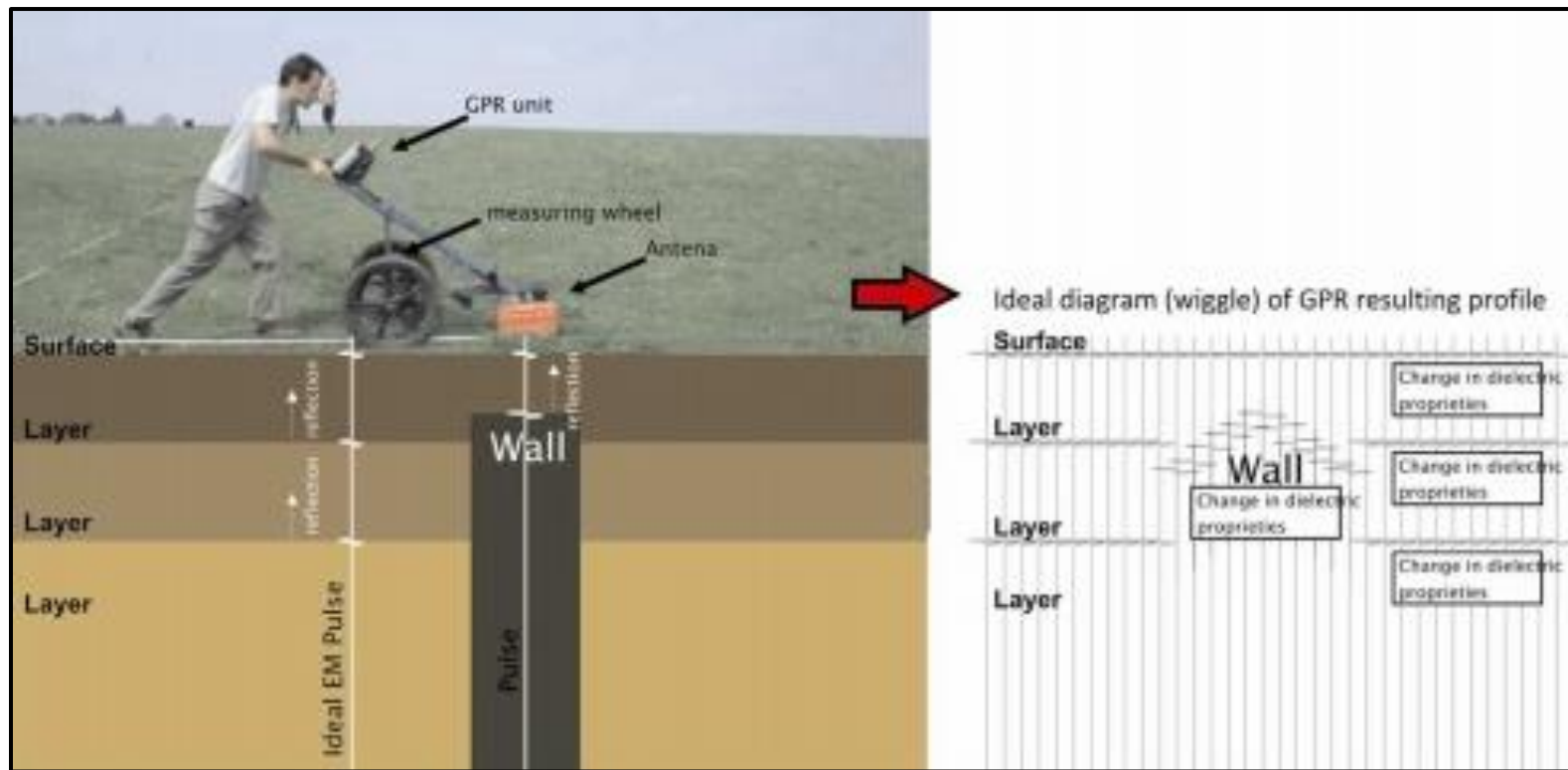


Figure 9: GPR Application and Change in RDP (Sala et al. 2012).



## **Survey Design**

There are four key components to any successful geophysical survey: adequate data sampling density, high-quality data, methodological field procedures, and apt data processing (Somers 2006:115). Adequate data sampling is collecting as many data samples per square meter as are required for the survey objectives. Taking more samples requires more time to collect samples, but this will increase the possibility of detecting finer features. Data quality relates to proper instrument configuration given the site setting, and data collection procedures in the field (Somers 2006:115).

Surveys can be conducted in blocks of any shape or size, but for ease of survey 20x20 m blocks are often used. The size, configuration, and spacing of the transects for data gathering are determined by the size of the area to be covered and the size of the features being surveyed. Larger grid blocks will take longer to survey than smaller blocks, but smaller blocks run the risk of surveying a limited area and potentially missing features of interest. Similarly, gathering data at a high density takes time, but provides a lot of data, while gathering data at low density will make it harder to detect smaller features. Data quality is monitored by the surveyor throughout the survey to ensure consistency in data gathering (Somers 2006:115).

## **History**

The first few geophysical surveys that were applied to study subsurface cultural remains were conducted in Europe in the 1920s and in North America in the 1930s (Conyers 2004a:4). However, these surveys were testing the effectiveness of the equipment and the resulting data was difficult to interpret (Gaffney and Gater 2003:14). Magnetic and electrical tools were primarily used for these early experiments, but the equipment, which was designed for mining and petroleum extraction, was not designed for an archaeological application. The resulting

anomalies were more related to geological features, rather than the presence of archaeological remains. It was not until the 1950s that geophysical equipment and surveys began to gain traction in archaeology (Conyers 2004a:4). Geophysicists began to experiment with different electrical and magnetic methods of calculating ground variation and conditions to potentially locate and map archaeological remains (Bevan 2000). These initial applications were effective in generating usable maps of subsurface sites, but were still crude. However, the results gained the attention of archaeologists, who were curious as to the benefits and application of the method.

Data collected from early geophysical surveys was recorded as points on paper and later hand drawn onto maps. Other pieces of data were recorded on magnetic tape, which was later digitized. With the introduction of computer technology in the mid-1980s, data processing became faster and geophysical equipment began to evolve rapidly. Data could now be recorded digitally on disks or tapes and be processed in a lab, rather than out in the field with the potential for incorrect interpretation (Conyers 2004a:5). The new technology also allowed for larger areas to be surveyed. The data density increased and the resulting maps and images were more precise. This is about when archaeologists really became interested in the application of geophysics to archaeological questions. Through the 1990s, the small geophysical archaeological community recognized the benefits and began applying the technology more frequently (Conyers 2004a:5)

One of the first applications of ground penetrating radar to archaeology in North America was in the American southwest at Chaco Canyon, New Mexico (Vickers et al. 1976). The 1975 study attempted to locate possible buried walls that were up to one meter below the ground surface. In these early studies, the encountered buried walls were described as “radar echoes” and depths were calculated by estimating velocity measurements from the local soil

characteristics (Conyers and Goodman 1997:18-19). Archaeologists on the eastern coast of the United States then began applying GPR to search for buried walls and underground cellars at historic sites.

After the success of these early archaeological applications of GPR, the next large-scale survey was conducted in 1979 on the Hala Sultan Tekke site located in Cyprus (Sheets et al. 1985) and the Ceren site located in El Salvador (Sheets et al. 1985). However, due to complications in processing, the Hala Sultan Tekke survey was unable to produce interpretable reflection profiles that could be used to differentiate subsurface features, such as walls, house platforms, and other features. At Ceren, the dry soils were nearly transparent to the radar and archaeological features in the resulting reflection records were relatively simple to analyze and interpret (Conyers and Goodman 1997:19).

In 1982 and 1983, another GPR survey was conducted at Red Bay, a sixteenth-century Basque whaling village in Labrador, Canada (Conyers and Goodman 1997:19). The purpose of this survey was to locate graves, buried artifacts, and/or house walls that could be associated with the village. Because of the village's natural topography and proximity to water, the soils were saturated and contained large amounts of gravel, which obscured radar reflections and made data collection challenging (Conyers and Goodman 1997:19). The artifacts and features were located approximately two meters below ground surface, underneath deposits of beach soils and peat. This GPR survey was the first in which velocity tests were analyzed to calculate the radar travel rate in order to convert radar travel time to an estimated ground depth (Conyers and Goodman 1997:21). After the survey was completed, some results were tested to validate the GPR results. It was discovered that some of the recovered artifacts, such as grave goods which consisted of metal and bone artifacts, did not contrast enough with the beach deposits and did not

create detectable anomalies. However, the disturbed soils from the graves and the large stones did contrast against the surrounding soils and were detectable (Conyers and Goodman 1997:20). This was the first recorded GPR survey to conclude that GPR was not the best suited to detect human remains, such as bones.

From the late 1980s and into the early 1990s, archaeologists continued to apply GPR successfully in multiple archaeological surveys and investigations (Conyers and Goodman 1997:20). Many of these surveys involved ‘anomaly hunting’ and were used to search for potential cultural features at undetermined or estimated depths. The purpose of the surveys was to investigate and detect with the GPR and then validate the GPR results with actual excavation. In the late 1980s, cultural resource management and preservation firms began to apply GPR more frequently in archaeological excavation and research. Ground-penetrating radar surveys were conducted on multiple site types including Fort Laramie in Wyoming (De Vore 1990), a Roman site in England (Stove and Addyman 1989), and the Illinois Rockwell Mount site (Doolittle and Miller 1991).

Ground-penetrating radar survey methods become more well-known after Sakayama Imai and T. Kanemori conducted a series of surveys in the mid-1980s to locate and identify subsurface sixth-century structures in Japan (Imai et al 1987). The results from this survey, along with later excavations, proved that GPR was capable of identifying deeply located features that had multiple cultural occupations. Other archaeologists, after seeing the success of Imai and Kanemori’s survey, began conducting more geophysical surveys on other house and mound structures in Japan (Conyers and Goodman 1997:20). Dean Goodman from the University of Miami Japan division, conducted a series of GPR surveys on historical structures from 1992 to 1995 (Goodman and Nishimura 1993; Goodman 1994; Goodman et al. 1994; Goodman et al.

1995). The studies furthered the developmental research for GPR data-processing and imaging techniques, resulting in the eventual development of the GPR-Slice software.

Further work by Sakayama Imai lead to the realization that radar reflections, which measure the time it takes for a signal to travel away from and back to the unit, could be used to define depths (Imai et al. 1987). With recent developments of two-dimensional computer simulation and three-dimensional processing techniques, the imaging and display of subsurface features has allowed researchers to process more fine-grained information about archaeological sites (Conyers and Goodman 1997:21).

Modern day GPR units are manufactured for applications other than that of archaeology, such as construction and geology. Most manufactures cannot develop and market these tools exclusively for the archaeological market alone, as there is not enough demand (Conyers 2013:7). As a result, the archaeological community must use geophysical methods and equipment that have been developed for other studies or fields. Because the equipment is not designed for an archaeological application, data collection and analysis techniques must be modified for archaeological needs. The processing software and imaging systems were designed to display buried pipes or geological deposits, which include anomalies that are deeper and larger than features archaeologists look for (Conyers 2013: 7). More recently, software and programs have been developed by archaeologists to specifically analyze GPR data from archaeological sites. Previously, there was little interest from archaeology students to learn about geophysics, because they lacked the ability to combine physics and/or math together to understand the geophysical data. With advancements in technology, more archaeology students, who are “digital natives” and familiar with computer applications in research, have become interested in geophysical applications, as well (Conyers 2013:7; Prensky 2001:1).

## **Theory**

Theoretical perspectives and designs are key in orienting the researcher with their data and directing the development of theses and conclusions. For the purpose of this thesis project, the theories selected focus on human interaction with and development of the natural landscape, and how those landscapes then functioned per the requirements of the occupants. Modernization theory and landscape theory highlight the functional aspects of the landscape at the historical sites that were surveyed for this project. Because ground penetrating radar is a methodological process in which the application and interpretation of the results is dependent upon the user having an understanding of the technical applications, there is less of a theoretical focus. To understand the application of the theories requires a brief discussion of their development and focus.

### **Modernization Theory**

Modernization theory was applied heavily by development scholars in the 1950s through the 1960s. An interdisciplinary approach, modernization theory is an abstract social theory that combines processes from sociology, history, psychology, anthropology, and economics. The theory was generated during World War II and was a political policy that applied Western concepts of industrialization and progress to justify unbalanced power relations between Third World countries and their First World counterparts. The approach was implemented to further develop capitalism in under-developed countries. The results of the Cold War further exaggerated the drive for capitalism and modernization was promoted to be an agent to protect Third World countries from the oppression of the Soviet Union and communism (Levy 1967; Preston 1982; Rostow 1960, 1978; Sanderson 1995).

Modernization theory was created to display the political and economic disparities between First World and Third World countries and thus tends to place societies within categories, such as traditional or modern. The model tends to refer to societies within a dichotomy: rich versus poor, etc. (Morner and Svensson 1991; Preston 1982; Roxborough 1988). Societies that place a greater emphasis on tradition have a tendency to be viewed as backwards and undeveloped in comparison to more modern societies. These more traditional societies tend to be more agricultural-based, reliant upon animate generated labor, have ascribed statuses, and maintain traditional, smaller scale social forms and are located within regions that have been generally described as Third World. In comparison, modern First World countries are more science based, industrial with earned status, and place greater economic value on individuals.

Modernization typically views processes in a phased linear progression of events and is heavily influenced by linear evolution and functional theory. It views events and results as being irreversible, progressive, and supposedly an improvement upon the previous landscape (So 1990). “As a generalizing, explanatory model, modernization theory also tended to ignore situationally specific historical processes and the way that individual societies progressed along typically unique and particular trajectories” (Groover 1997). Because of its linear orientation and uni-directional projection, the theory assumed that all societies are comparable, no matter their location in space or their orientation in time. Modern historical cases prove that this assumption is false and societies experience different development and adaptive processes unique to that society. By the later 1960s, researchers began to acknowledge that modernization theory was not a viable explanation for development and the theory has thus been reevaluated and redeveloped. The modern application of modernization theory is that modernization of a society is regarded as theory of development. The theory now acknowledges that other factors,

such as internal and external forces, will have a great effect on development and that modernization is a result of technological, agricultural, and industrial influences, which includes urbanization. The theory also now acknowledges that each instance of development is unique per application and varies between each case.

Despite its shortcomings (modernization theory still forces a dichotomy and attempts to organizes cases into characteristics based upon the level of modernization/technology), modernization theory provides the possibility for the researcher to understand the unique incorporation of regional development, new technologies, class organization, and gender roles, for instance. For the purpose of this project, modernization theory is being applied to organize the discussion and presentation of surveyed sites in a linear fashion and aid the interpretation of modern features. Sites will be organized and presented with the earliest site being discussed first and the most modern site being discussed last. The ‘modernity’ of a site is being judged by the time range of site occupation/duration. Modernization theory is also being applied to anomaly interpretation. Typically, within the application of historical archaeology, features that have been determined to be modern in nature (younger than 50 years) are typically dismissed and labeled as modern and of no interest. This study will apply modernization theory to explain the presence of anomalies determined to be more modern. Modernization theory is most apt when looking at how landscape and technological developments affect the footprint or foundations of previous structures. Modernization is a linear process and through the review of anomaly creation, the modern developments of a site can be recreated. The application of modernization theory assists with site interpretation and explanation of features in correlation with the landscape in a chronological order.



## **Landscape Theory**

Landscape theory is the study of the ways that past peoples have constructed, altered, and/or lived in the environment(s) around them (Rossignol and Wandsnider 1992: 4). Since GPR is utilized for the purpose of locating subsurface features in orientation to known (or unknown) surface markers, landscape theory is the most prudent theory to guide grid orientation and determination of grid placement. The theory is multidisciplinary in its approach to studying culture and the past, in that it incorporates settler colonialism studies, environmental studies, archaeology, and cultural anthropology to understand how humans have interacted with their environment in different time periods and places. The application of landscape theory would allow for analysis of how the landscape would influence the orientation and construction of structures and how interpretation of artifact and feature locations would suggest the locations of such structures.

“The study of landscapes began in the Cultural Historical School and continued in the work of Processualists, with most attention to how humans interacted with the environment” (Urban and Schortman 2012: 166). With historical archaeology, landscape theory is used to analyze the distribution of artifacts and features across a landscape to understand how humans adapted to their geographic surroundings and exploited the resources of the area or altered the landscape to fit their needs. The application of GPR with landscape theory also has the added benefit of testing for ambiguity between primary documentation and physical features. The primary documents consulted include written records, photographs, Sanborn fire insurance maps, and plat maps. Three of the five surveyed sites had accessible primary documents available for analysis.

Landscape theory is applied prior to survey in order to assist with grid orientation. Additionally, knowledge of the topography and soils of the survey area is required to properly calibrate the GPR equipment to function most suitably for the soil type(s) in the survey area.

### **Settler Colonialism Theory**

Settler colonialism theory is applied very briefly in this thesis. All sites to be discussed have the common theme in that they are historic and are influenced by settler colonialism. Settler colonialism, as noted by Patrick Wolfe, destroys to replace (Wolfe 2006: 388). It is the process of the erasure of the indigenous population by new settlers, who also strive to differentiate themselves from the settler's mother country (Wolfe 2006:389). The process of settler colonialism does not just replace the indigenous culture in one event; replacement is gradual. This includes the introduction of new material goods, agricultural practices, and cultivation methods. Settler colonialism is characterized by a number of features, such as settlers who permanently stay. Settler colonialism is a structure, rather than an event, and the ultimate goal is to settle, to create, and to maintain. As noted by William Cronon (1983), economic and ecological imperialisms reinforce each other, and change in one will be visible in another. Because settler colonialism had a set pattern of invasion and construction, those same construction patterns are reflected in landscapes affected by settler colonialism. In this sense, consistent patterns of landscape development are reflected in all landscapes that experienced settler colonialism. Settler colonialism can be applied after identification and can reveal a lot about how people lived in the past. How the landscape was used and the nature and arrangement of archaeological remains, and how together these reflect social class, economic income, and the number of individuals who used the site are just some of the questions geophysics and settler colonialism can address.

## Indiana's Topographic History

To effectively survey and interpret GPR data, the researcher needs to have an understanding of the geological setting the site is located on. Soil composition and drainage greatly influence and impact the results of the radar survey. Indiana has had relatively few geophysical surveys and in order to select the most effective method for any given survey, the researcher needs to understand what soil types are present.

Indiana's geological history consists of a series of geological uplifts and glacial impact. Indiana's bedrock is comprised of sedimentary rock that is a combination of sands, silts, and clays, which were deposited by streams and oceans from 300 to 450 million years ago (**Error! Reference source not found.**) (Jackson 1997:8). Other parts of the United States have experienced similar episodes of sediment deposition, but have had subsequent millennia of deposition, covering the earlier sedimentary rocks. Because the Indiana landscape was above sea level, the later-deposited sediments were exposed and eroded away naturally, exposing the older bedrock.

### Bedrock

All of Indiana's bedrock, which is either exposed on the surface or rests just below the surface, dates to the Paleozoic period. The older Precambrian rocks are exposed in parts of the state, but they mainly lay deep beneath the Paleozoic rocks. However, due to erosion, the Mesozoic rocks, which are superimposed upon the Paleozoic rocks, have all been eroded from the Indiana landscape and any rocks which date to the Cenozoic record, which are very few, were deposited during Pleistocene glaciations. Because of this record being highly eroded, there are very few fossil remains to be recovered from Indiana, as many of the dinosaurs that would

have walked the Indiana landscape dated to the Mesozoic record, which was eroded.

Alternatively, if the glaciers from the ice age had not deposited so much sediment, mammoth and mastodon fossils dating to the Cenozoic era would be much harder to discover (Jackson 1997:3-13).

As discussed earlier, the Indiana rock from the Paleozoic era is sedimentary bedrock. Sedimentary rock is formed when sediments, which have been deposited in layers, become compacted by the weight of over-lying materials or by being cemented by groundwater. While Indiana displays a variety of different rock types, Indiana is famous for its limestone. Limestone is formed in shallow, tropical marine waters (Jackson 1997:7). With the exception of the anomalous rocks located in Kentland, Indiana's bedrock has been tilted only a little bit since its formation, but none has been overturned. Thus, bedrock closer to the ground surface is younger and it gets progressively older with depth.

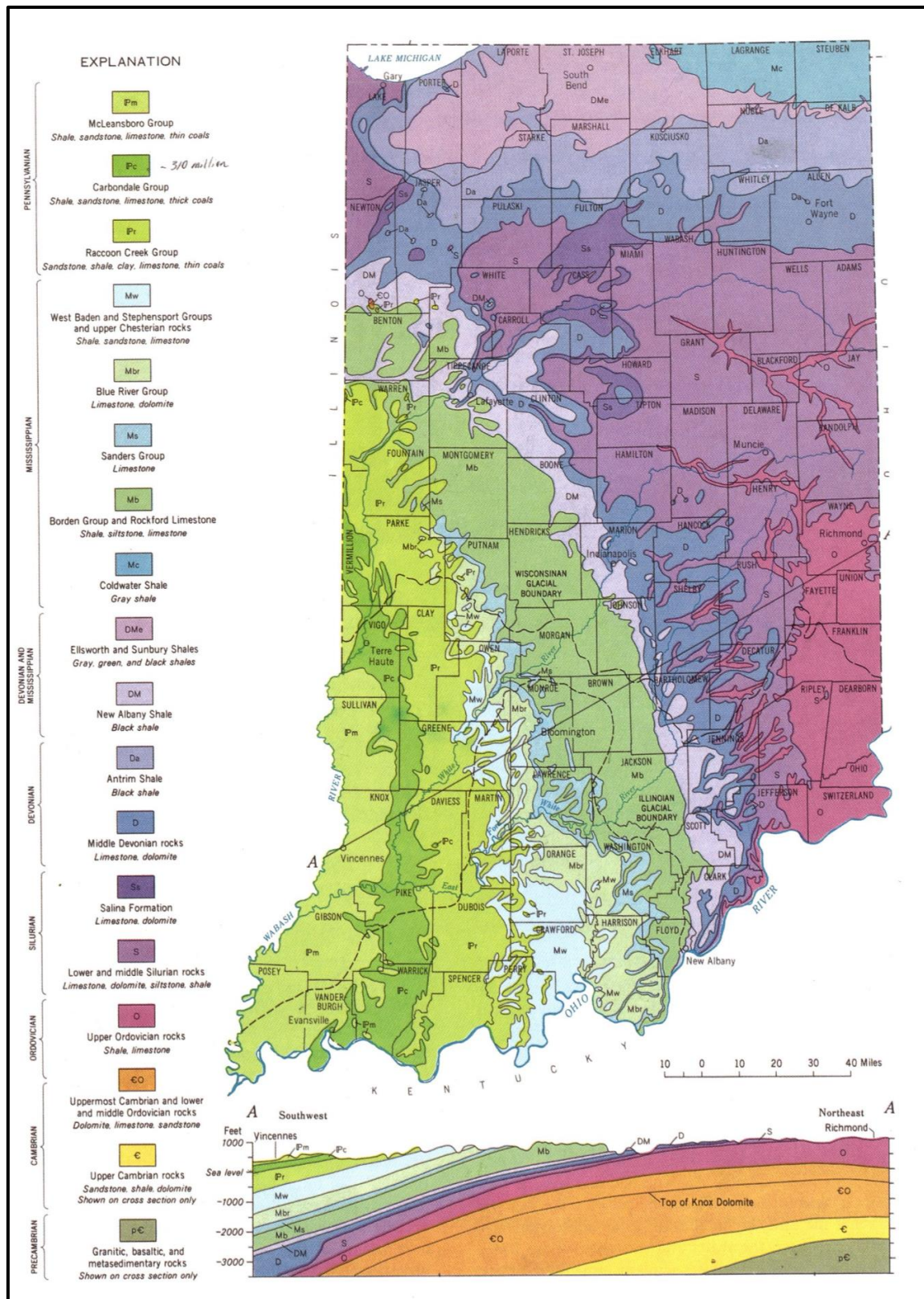


Figure 10: Bedrock Regions of Indiana from the Natural Heritage of Indiana (Jackson 1997:8.)

## **Glaciation**

From 2 to 2.5 million years ago, the global climate drastically shifted and entered into the Great Ice Age. The Theory of Continental Glaciation, first proposed in Europe in 1821, is applied to express causation for glaciation (Jackson 1997:15). It is generally agreed that glaciation is a result of short- to long-term climate trends occurring between the atmosphere and the oceans. However, each specific variation of glaciation can be influenced by a diversity of cosmic or terrestrial influences. It was first assumed that the glaciation process itself took several centuries or even millennia. However, new evidence suggests that this process, of either glacial formation or melting, can be accomplished within a few hundred, or less, years (Jackson 1997:15).

The word moraine comes from glacial theory, first introduced in 1821 by Ignatz Venetz-Sitten, a Swiss civil engineer who presented it to the Helvetic Society (Raukas 2008). Moraine refers to piles of debris which are residual from when a former ice front was static. However, the original ideas of how glaciers formed, moved, melted, and left a debris record differs from the modern interpretation of glaciation (Jackson 1997:16). Based upon glacial studies done in the lower Great Lakes, in which field scientists observed and calculated field evidence of topography and characteristics of glacial deposits, it is now hypothesized that the most recent glaciers were the result of surges or ice streams. These surges did not cover the landscape for long and were relatively thin ice tongues which advanced quickly, stagnated, and then rapidly melted (Jackson

1997:18). In Indiana, much of the area scientists thought was glaciated actually lacks the long debris zones characteristic of moraines, which were the residual evidence of long-term glaciers as seen in Figure 11. Secondly, almost all of Indiana displays evidence of rapid death or melting of the stagnant ice (Jackson 1997:20). Evidence from the stagnant ice is the vast expanse of ground moraines, which are gently sloping landscapes with abundant depressions and organic deposits, formed in small hollows created by melting ice blocks (Jackson 1997:18). These ground moraine features are plentiful in the northern half of the state and become less prevalent farther south as seen in Figure 11 and Figure 12 (Jackson 1997:16).

Glaciation, including rapid formation, stagnation, and melting, results in the deposition of large quantities of debris. This debris is rich in nutrients, creating nutrient rich soils beneficial for an agrarian economy. Much of the state's biological and agricultural richness is due to the Ice Age glaciers (Jackson 1997:18-19).







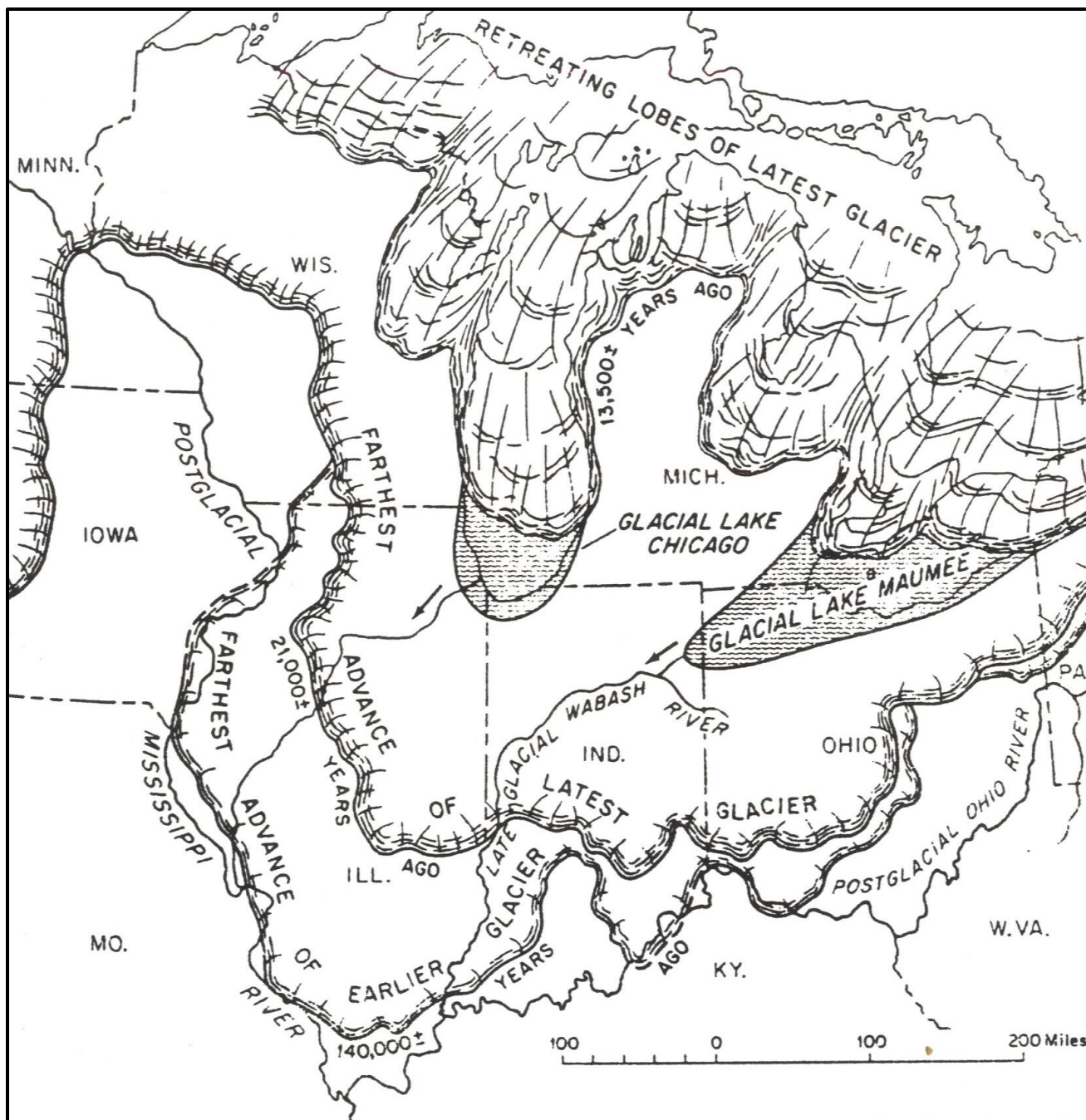


Figure 12: Extent and Impact of Glaciers in Indiana (Jackson 1997:16).

## Soils

The state of Indiana has thirteen soil regions comprised of different soil types: sandy soils, soils on water-deposited materials, soils formed in thick loess, soils formed in Wisconsinan glacial till, soils on Illinoian glacial till, soils formed on clastic bedrock, and soils over limestone (Hillel 1991). Indiana's different soil regions are shown in Figure 13. Regions 1 and 4 are comprised of sandy soils and are deposited and moved by water and winds, forming sand dunes. Region 1 is located exclusively in the northwestern corner of the state, while Region 4 is found in north-central and southwestern Indiana (Hillel 1991). Regions 2 and 3, scattered throughout Indiana near water, are formed in glacial outwash, lake deposits, and alluvium and are found on outwash plains and terraces. Outwash plains are typically located in upland settings, while the terraces are normally enclosed in a river valley setting. Region 2 and 3 soils normally develop in coarse materials that settled in outwash streams and were then covered by finer grained materials, so soils are a loamy material transposed over sandy/gravelly material. Typically, the surrounding landscape is broad and flat and the soil can be poorly drained to well drained, depending on how deep or shallow it is. The soil is rich, due to the process of its formation and is ideal for crop cultivation. However, the farmer needs to be careful, as too much leaching of the soil will remove the nutrients and the soils may be difficult to drain, due to high clay content (Hillel 1991).

Region 5, situated along the Lower Wabash River and the White River in the southwest region of Indiana, is covered by thick loess (Hillel 1991). These loess soils are loose, which allows for water and roots to penetrate and move through the soil with ease, and as a result the soils hold water well. Again, these soils are good for agricultural, however, because these soils are loose, they need to be covered to reduce erosion (Hillel 1991). Regions 6, 7, 8, and 9 were formed from Wisconsinan glacial advancements around 21,000 years ago. The glacial advance ground and mixed up previous material and the remaining, leveled landscape is called a ground moraine or till plain. At their front edges, the glaciers created end moraines. This landscape feature can be found in central and northern Indiana and is called the Tipton Till Plain (Hillel 1991).

Region 10 has been referred to as the Illinoian Till Plain because it was once thought that the soils in this region developed within Illinoian glacial till. However, recent work suggests that they were deposited earlier (Hillel 1991). The plains are broad and flat and are located in the southern half of Indiana. The soils in this region were developed during the warmer interglacial time, eroded, and then covered by about 101 to 254 centimeters (40 to 100 inches) of loess during the Wisconsinan time (Hillel 1991). Regions 11 and 13 are located in south-central Indiana, where the topography is rugged and the soils are formed in decomposed bedrock (Hillel 1991). Because the glaciers never reached that far, the rocks in Regions 11 and 12 are relatively undisturbed, including sandstones, siltstones, and shales (Hillel 1991). Water cuts through the

rock and runs off, creating drainage systems comprised of narrow ridgetops and steep side slopes (Hillel 1991).

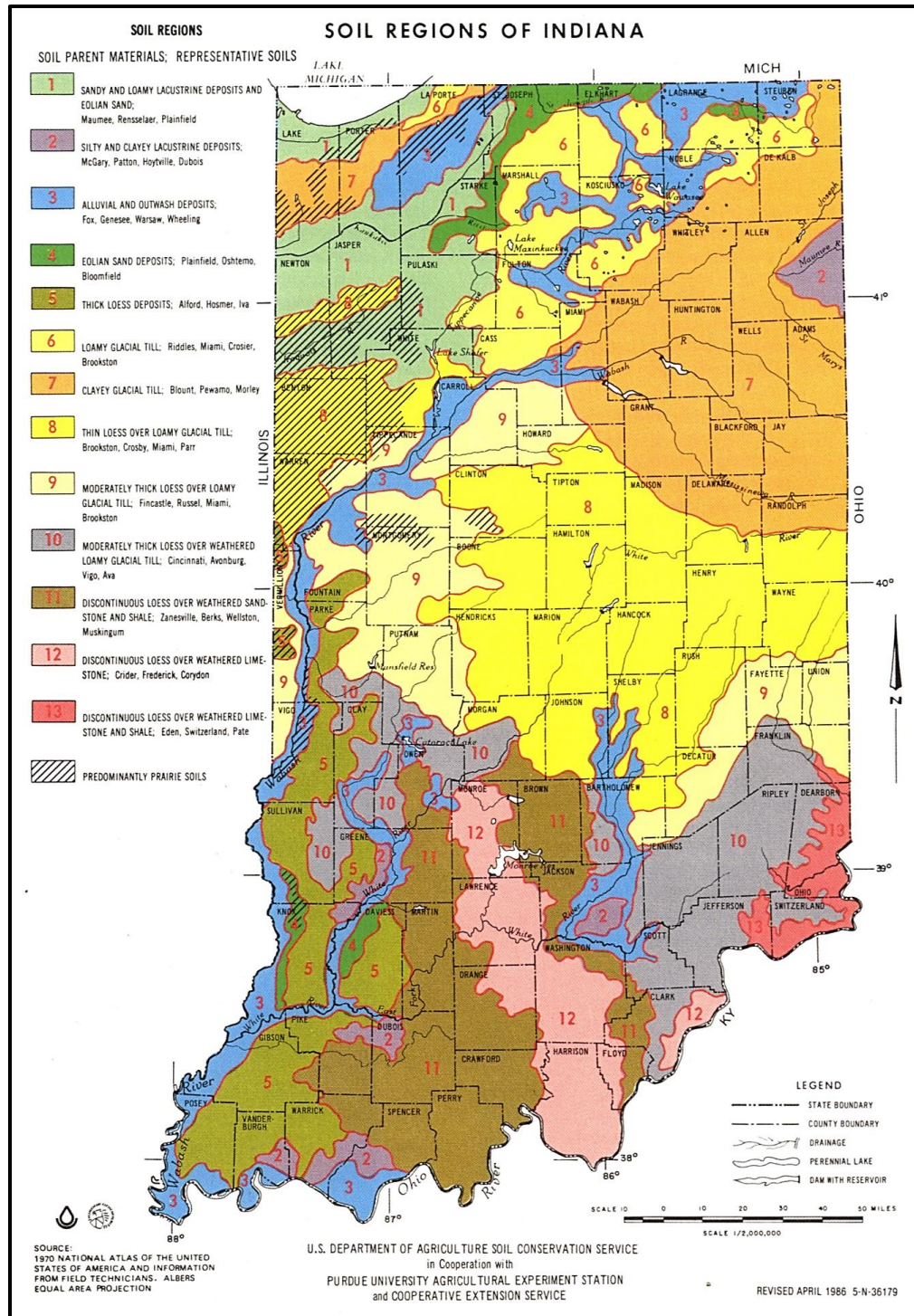


Figure 13: Soils Regions of Indiana (Jackson 1997:48).

Region 12, located in south-central Indiana, is comprised of soils formed over limestone (Hillel 1991). Even though Regions 11 and 13 are adjacent to Region 12, the drainage pattern between the three is drastically different. Region 12 is comprised of limestone, and water is able to penetrate the limestone and dissolves it to form a subsurface drainage network, while also creating sinkholes (Hillel 1991). Very few surface streams are found in Region 12 and they only form with heavy rains. The landscape is dotted with sinkholes, creating areas referred to as karst plains (Hillel 1991). The slopes of Region 12 are moderate and are easily eroded, as seen in Regions 11 and 13.

## State Reported Surveys

A literature review of Indiana geophysical surveys was conducted to determine the number of surveys performed in the state and illustrate what kinds of feature characteristics other researchers are looking at when identifying geophysical anomalies. In March, 2017, as part of this research, a records check was conducted to research any geophysical reports submitted to the Division of Historic Preservation (DHPA) for the state of Indiana. A search on the State Historic Architectural and Archaeological Research Database (SHAARD) produced forty-one reports with a geophysical component that had been submitted to the state (SHAARD 2017). Of the 92 counties in Indiana, geophysical surveys have been completed in 19 counties (Adams, Allen, Clark, Dearborn, Gibson, Greene, Hamilton, Jennings, Johnson, LaPorte, Marion, Monroe, Pike, Porter, Posey, Spencer, Tippecanoe, Vanderburgh, and Washington) and are displayed in Table 1. The reports include one or multiple geophysical methods (GPR, electrical resistivity/resistance, magnetometry, magnetic susceptibility, seismic, etc.). Out of the 41 reports, fifty-four percent (n=22) of surveys had a magnetometry component, fifty-one percent (n=21) of surveys had an electrical resistance/resistivity component, and forty-four percent (n=18) of surveys had a GPR component. Seven percent (n=3) of surveys had a seismic component, five percent (n=2) of surveys had a metal detection component, and 2 percent (n=1) of surveys had a magnetic susceptibility component. The results of this review show that GPR has been used nearly as much as the other main methods. It should also be noted that 51 percent (n=21) of surveys used multiple geophysical methods, as is suggested for a more complete interpretation of subsurface features.

Table 1: Geophysical Reports from SHAARD (SHAARD 2017).

County	Geophysical Method(s)	Type	Comments
Adams	Electrical Resistance	Construction	Peterson and Martin 2008
Allen	Ground Penetrating Radar and Magnetic Gradiometer	House	Weddell 2005
	Electrical Resistivity, Ground Penetrating Radar, and Metal Detection	Fort	Andres et al. 2008
Clark	Magnetic Gradiometer and Electrical Resistance	Cemetery	Burks 2005
	Ground Penetrating Radar	Cemetery	Graham 2011
	Magnetic Gradiometer, Ground-Penetrating Radar, and Electrical Resistivity	Mound	Munson et al. 2006
Dearborn	Magnetic Gradiometer, Magnetic Susceptibility, and Ground Penetrating Radar	Construction Cemetery	Schwarz et al. 2015 Peterson 2006
	Ground Penetrating Radar	Cemetery	Nolan 2016
	Magnetic Gradiometer	Native American Village	Cook and Martin 2013
	Ground Penetrating Radar	Construction	Peterson 2016
Gibson	Magnetic Gradiometer, Electrical Resistance, and Ground Penetrating Radar	Cemetery	Graham and McCullough 2007
Greene	Electrical Resistance	Cemetery	Trader 2010a
	Electrical Resistance	Cemetery	Trader 2010b
Hamilton	Magnetic Gradiometer, Electrical Resistivity, and Seismic	Fort, and Native American Village and Mound	Gansfuss 1977
	Ground Penetrating Radar	Native American Village	McCullough et al. 2004
Jennings	Magnetic Gradiometer, Electrical Resistance, and Ground Penetrating Radar	Four prehistoric camp/villages, one lithic scatter, two rockshelters, and two cemeteries	Peterson et al. 2008
Johnson	Electrical Resistivity and Ground Penetrating Radar	Cemetery	IPFW Archaeological Survey 2008



County	Geophysical Method(s)	Type	Comments
<b>Johnson</b>	Ground Penetrating Radar	Cemetery	Andres et. al 2007
<b>LaPorte</b>	Magnetic Gradiometer and Electrical Resistivity	Mound	Schurr 1999
<b>Marion</b>	Electromagnetic Metal Detector	Streetcar Rails	Vanderlaan 2010
	Ground Penetrating Radar	Construction	Stuehrenberg 2016
<b>Monroe</b>	Magnetic Gradiometer and Electrical Resistivity	Cemetery	Ball 1994
<b>Pike</b>	Seismic	Construction	Martin 2016
	Seismic	Construction	Miller and Martin 2016
<b>Porter</b>	Magnetic Gradiometer and Electrical Resistivity	Lodge	Schurr and Wells 2011
	Magnetic Gradiometer and Electrical Resistivity	Mound	Schurr 2014
	Magnetic Gradiometer and Electrical Resistivity	Homestead	Schurr and Wells 2014
	Magnetic Gradiometer, Electrical Resistivity, and Ground Penetrating Radar	Lodge	Schurr 2011a
	Magnetic Gradiometer and Electrical Resistivity	Mound	Schurr 2013
	Ground Penetrating Radar	Lodge	Schurr 2011b
<b>Posey</b>	Ground Penetrating Radar and Magnetic Gradiometer	Kiln Dormitory	Strezewski 2013
	Magnetic Gradiometer		Strezewski 2014a
<b>Spencer</b>	Earth Resistivity, Magnetic Gradiometer, and Ground Penetrating Radar	Homestead and Mill	Peterson et al. 2010
<b>Tippecanoe</b>	Magnetic Gradiometer	Native American Villages	Strezewski 2014b
	Magnetic Gradiometer	Native American Village	Strezewski et al. 2007
	Magnetic Gradiometer and Electrical Resistivity	Native American Village and battlefield	Strezewski and McCullough 2006
<b>Vanderburgh</b>	Magnetic Gradiometer and Electrical Resistance	Historic Town	Peebles and Weymouth 1989
	Ground Penetrating Radar Magnetic Gradiometer	Canal Mounds	Pye and Head 2016 Strezewski 2014c
<b>Washington</b>	Magnetic Gradiometer and Electrical Resistivity	Prehistoric Village	Graham 2008



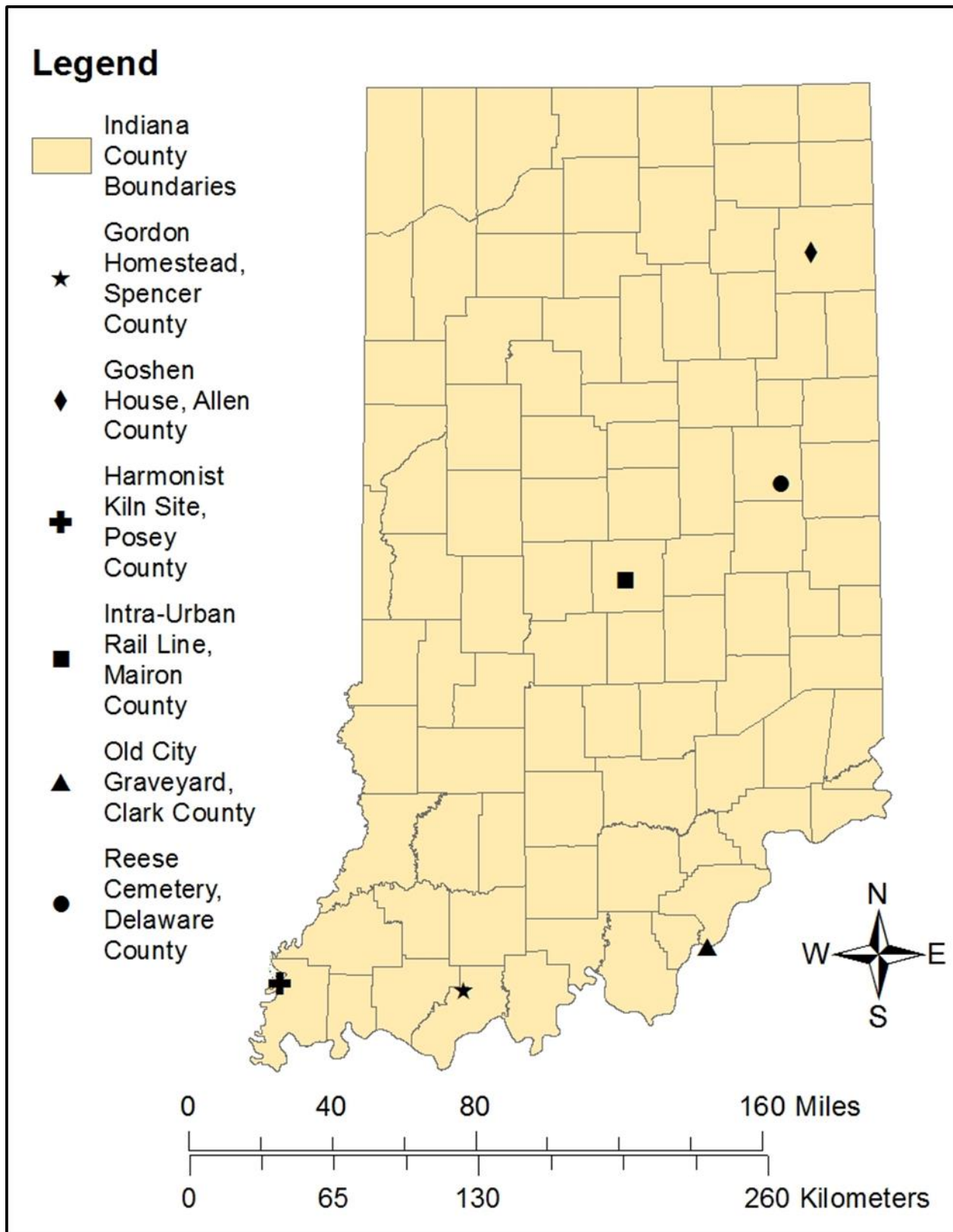


Figure 14: State Reported Survey Locations in Indiana.

As indicated by the results of the records check, multiple geophysical survey methods have been applied to a variety of prehistoric and historic sites throughout the state of Indiana, and with varying degrees of success.

Settler Colonialism is a structure, a process of removal of indigenous culture(s), replacing them with an invading foreign culture, and then ensuring the complete removal of the indigenous culture by introducing new technological advancements. This framework of gaining control through invasion is a consistent pattern visible in multiple sites that experienced settler colonialism, reflected in the developing landscapes. The landscape changes would have reflected the removal of any indigenous features and the installation of the settler culture. The first early settler colonial sites all show an almost complete landscape transformation, with tree and brush cleared to make an open space for a collective of structures, such as the structural layout of the Harmonist Redware Kiln site and the Gordon Homestead display. The clearing of the original natural landscape and replacing it with a geometric system was meant to imply the disconnect from the Native American cultures. The same systematic approach of arranging features is reflected in the organization of cemeteries. Graves from the Reese Cemetery and Old City Graveyard are arranged within a geometric framework, while also openly displaying Catholic religious symbols to encourage the removal of Native American religious practices.

To further the installation of settler colonialism, technological developments ensure that the invading culture will continuously be updated and reinforced. The Rankin House was an early settler colonial house that displayed the technical advancements with plumbing updates taking place to keep the house functional and active on the landscape. These processes of updating are continuous throughout all landscapes that continued to be affected by settler colonialism. The technological updates reflect the monetary growth within the intruding culture,

with the most accelerated expansion being seen in larger cultural centers such as cities. Smaller, more isolated areas will still have technical updates, to continue reinforcing the invading culture and ensure that the indigenous culture was removed. However, those updates are on a smaller scale and less frequent.

The process of settler colonialism is not restricted to just the past and is a process that is continuous even today. This process has continued up into the modern day and is displayed in the landscape visible at the Intra-Urban Line site. All landscapes affected by settler colonialism will display characteristics of rapid landscape change up into the modern day and the sites selected to be discussed for the state surveys reflect that development of settler colonialism in Indiana

Another purpose of the records check was to review what anomaly characteristics other researchers look for when identifying GPR anomalies. Since this thesis consists of five sites (one cemetery, one domestic structure, two specialty structure, and one modern site), a selection of similar type (n=6) were examined in greater detail, including two cemetery sites, two domestic structure sites, one specialty site, and one modern site (**Error! Reference source not found.**).

### **Cemeteries**

Cemeteries have always been an interest of archaeological researchers, due to their unique purpose and the type of information that can be collected. Geophysical methods can be very useful, non-invasive research tools in cemeteries. The three most effective geophysical methods for cemetery research are GPR, electrical resistance, and magnetic survey (Jones 2008:25). While multiple geophysical survey methods often are used to generate effective survey results, GPR surveys have had the most success in cemeteries. They can detect small targets at greater depths than other methods (Jones 2008:26). However, Jones (2008) notes that GPR can

be severely limited by site condition. Generally, sandy, homogenous soils are the best conditions for a GPR survey. “Clayey, silty, and alkaline soils tend to have high electrical conductivity, which can cause excessive attenuation (conductive loss) of the GPR signal, limiting both depth of investigation and resolution” (Jones 2008:27). Soils that are rocky, extremely heterogeneous, have excessive moisture or large amounts of metal, are in rough terrain, and have excessive physical obstacles all negatively impact the effectiveness of GPR surveys (Jones 2008:27).

### **Reese Cemetery, Muncie, Indiana**

According to the State Historic Archaeological and Architectural Research Database (SHAARD), there are 10,930 state defined and recorded cemeteries in Indiana (SHAARD 2017). Cemetery types recorded in SHAARD are a combination of historic and prehistoric and cemetery types include Adena, African American, Amish, Fort Ancient, Mound culture, Scottish, and Winnebago, just to name a few. Many of the cemeteries throughout Indiana have long histories, dating back to the settlement of Indiana in 1816 and earlier when it was part of the Northwest Indian Territory (Byer and Mundell 2003:1). Some cemeteries are being maintained by historical societies, while others have seemingly been forgotten and abandoned.

Reese Cemetery, located in Delaware County, Indiana, represents one such cemetery that experienced a period of neglect before it came under the protection of the cemetery association. Gregory Byer and John Mundell, from Mundell & Associates, were retained by the Reese Cemetery Association to assist in the documentation of existing marked graves, to map the marked graves, and to apply geophysical methods to identify potentially unmarked graves. Following Indiana law and regulation IC 14-21-1, no activity which could have disturbed the ground was used during the survey (Byer and Mundell 2003:2). Geophysical methods are permissible under Indiana law, but ground-truthing is only permissible with an approved

Archaeological Plan. Ground truthing is the practice of enhancing and verifying geophysical results with primary resources (Hargrave 2006: 269). Hargrave (2006) notes that the word *truthing* does not suggest that the primary source might be invalid. In addition, the Reese Cemetery Association wished to respect the families of the deceased and did not allow excavation. Ground penetrating radar, metal detection, and electromagnetic conductivity were selected prior to survey, as they were the most suited methods. Bruce Bevan in “*The Search for Graves*” noted that graves can potentially be identified through several characteristics in Table 2 (Bevan 1991: 1310-1311).

Table 2: Typical Grave Characteristics

<ul style="list-style-type: none"> <li>• Disturbed soils from filling excavation. May results in higher or lower electrical conductivity from surrounding, undisturbed soils.</li> <li>• Human decay may alter grave chemical composition.</li> <li>• Intact coffin may cause air pocket.</li> <li>• Metal fixings from coffin can be detectable.</li> <li>• Burial vault made of stone or brick can cause air-pocket and materials can be magnetic.</li> <li>• Soil settlement from grave shaft may cause surface depression. Topsoil may settle in depression, causing a lens.</li> <li>• Metal objects, headstones, and footstones may be found in proximity to the grave.</li> </ul>
Bevan 1991; Byer and Mundell 2003

Bevan (1991) noted that GPR had the highest success of locating unmarked graves and the best conditions for grave location was when the soil conditions were not complex, with little to no stratification. David Nobes, in “*Geophysical Surveys of Burial Sites: A Case Study of the Oaro Urupa*” notes that clayey conditions can severely reduce the effectiveness of GPR (Nobes 1999:358). Indiana has a high clay composition in most soils, which greatly impacts GPR results.

Reese cemetery is located two miles southeast of Muncie, Indiana, and is on a slight rise, as most cemeteries are (Byer and Mundell 2003:4). “Reese Cemetery is approximately one acre (0.4 hectare), and contains graves spanning at least a 181-year period from 1819 to 2000” (Byer and Mundell 2003:4). During the site survey, a ten foot by ten foot grid was established and all

of the standing headstones were photographed, recorded, and mapped. The positioning of the headstones suggested that the arrangement of graves was by date, with the oldest headstones being located on the top of the rise and the more recent graves going down the slopes (Byer and Mundell 2003:6).

Two electromagnetic surveys were conducted over the entire survey area. The first survey utilized a Geonics EM-61 metal detector, which was used to characterize the distribution of buried metallic objects (Byer and Mundell 2003:7). The EM-61 is a high-sensitivity metal detector that generates a magnetic field and detects the fields of local metal objects. The decay of induced currents was measured for a long time after the termination of the primary pulse, so that the generated, recorded response is almost independent of the effects of soil conductivity (Byer and Mundell 2003:7). The EM-61 is useful because it detects both ferrous and non-ferrous materials, and it has a response curve that is a single, easily interpreted peak (Byer and Mundell 2003:7). The second electromagnetic instrument applied was a Geonics EM-38 terrain conductivity meter, which was used to map the soil conductivity of the cemetery. The results of the EM-61 with the EM-38 provide an aerial view of mapped metallic objects and soil disturbance features. Additionally, a 250 megahertz GPR unit was employed to supplement the electromagnetic survey results (Byer and Mundell 2003:8). Transects were surveyed in a south to north orientation and a total of 43 transects was gathered (Byer and Mundell 2003:9).

The combined results of the three survey methods indicated that dominant features from each of the surveys corresponded with subsurface metallic objects. The GPR results appeared to have mapped individual graves with metallic objects and several other anomalies that lacked metallic objects, which were located within the older portions of the cemetery. The electromagnetic results did not fare as well as the GPR for detecting individual graves and

instead had a tendency to merge graves into larger anomalies (Byer and Mundell 2003:11). Ground-penetrating radar was the only method employed that was able to reliably locate individual graves, based upon disrupted soil stratigraphy, while the EM-38 was able to provide insight on metallic object distribution and variations in soil conductivity. Employed together researchers were able to create a relatively accurate map of grave distribution in Reese Cemetery.

### **Old City Graveyard, Jeffersonville, Indiana**

In 2011, the Indiana University-Purdue University Fort Wayne Archaeological Survey (IPFW-AS) was contracted to conduct a ground-penetrating radar (GPR) geophysical survey of a section of the Old City Graveyard in Jeffersonville (Graham 2011:2). The purpose of the investigation was to apply non-invasive remote sensing techniques to locate the presence or absence of unmarked graves in the cemetery. The cemetery is located in a baseball field in downtown Jeffersonville; no headstones or depressions are visible at the surface (Graham 2011:2). Before the survey was conducted, the field conditions were evaluated. Several factors can interfere with geophysical instruments at archaeological and historical sites. These factors include, but are not limited to: visibility, soil composition, vegetation, moisture, anomaly characteristics, the presence of ferrous objects, and cell phone/radio transmission (Graham 2011:3). It was noted before the survey that the field conditions were not entirely favorable. There had been recent grading or cutting of the topsoil, the ground was saturated, and the location was in an urban setting. The short grass allowed for efficient survey, but the saturated soils and potential for urban disturbances and fill ruled out the application of electrical resistance (Graham 2011:4). Ground-penetrating radar was determined to be the most suited method for the setting.

Prior to the survey, a grid was oriented north-south and incorporated a portion of the baseball field. The grid positioning was limited due to the presence of the dugout and fence, but a 100 m by 70 m grid was established. The data were gathered using a Geophysical Survey Systems TerraSIRch SIR System 3000 with a 400 MHz antenna. The system was set up to take 512 samples per scan with a dielectric of 12 at 50 cm transect-intervals. GPR-Slice v7.0 was used for data processing (Graham 2011:5). The GPR results indicated several potential grave features. A total of 25 time slices were produced that showed anomalies at different depth increments. Several anomalous, irregularly-shaped features were noted. It is thought that these features are caused by near surface fill deposits, such as rock. Other features located in proximity to Mulberry Street are thought to be associated to previous residential structures (Graham 2011:7). Several strong and subtle features in the western, central, and southern portions of the grid were detected and interpreted to be grave related. These features were best observed in the radargrams (Graham 2011:7). However, the IPFW-AS researchers indicate the methods and instruments used in the investigation had the potential for error and that given the field conditions, such as saturated soils and the presence of urban features, the interpretation may not have identified all the graves (Graham 2011:22).

### **Summary of Cemetery Results**

The goal of each survey was to locate and identify grave features in each respective cemetery. As noted by Bevan (1991), sites with a higher clay content or more complex soil matrix make it more difficult for the geophysical equipment to detect grave features. In Reese Cemetery, electromagnetism was used to detect metallic objects and to measure soil conductivity (Byer and Mundell 2003). Ferrous objects were more numerous in the newer section, while there was a lower presence of ferrous materials in the older section. The soil conductivity survey



tended to merge adjacent graves into one large mass, instead of displaying them as individual graves (Byer and Mundell 2003). The GPR survey proved more effective, because it was able to distinguish individual graves in the soil stratigraphy. Byer and Mundell identified GPR grave anomalies by looking for interruptions in the soil stratigraphy that were created when the grave was first dug and then filled in (Figure 15).

The Old City Graveyard GPR survey in Jeffersonville was also conducted with the intent of identifying graves. Unfortunately, there were no headstones to indicate the potential location of graves or reveal grave patterns. Graham (2011) noted several features of interest from the survey. Several irregular features that were near surface fill deposits were thought to be grave features until it was determined they were associated with construction debris. Several other features in proximity to the street were thought to be modern in nature and a reflection was detected in association with the infield of the baseball field (Graham 2011).

The most beneficial information learned from these case studies was the information presented in Table 2, in which Bevan 1991 and Byer and Mundell 2003 both noted typical grave characteristics they had seen in previous surveys. These characteristics are what I will be looking for in the Nottingham Cemetery data. In each survey, both researchers looked for gaps in the soil stratigraphy to identify features as being grave related. In the case of Reese Cemetery, that method proved successful, while in Old City Graveyard it proved to be challenging due to the presence of new features and saturated soils. Considering the Nottingham Cemetery survey was also conducted when the soil was highly saturated due to recent rainfall, there is a potential that the results may be distorted. However, since there is no history of other soil disturbance taking place on the site, I am hoping that the presence of the water will enhance gaps left by graves.

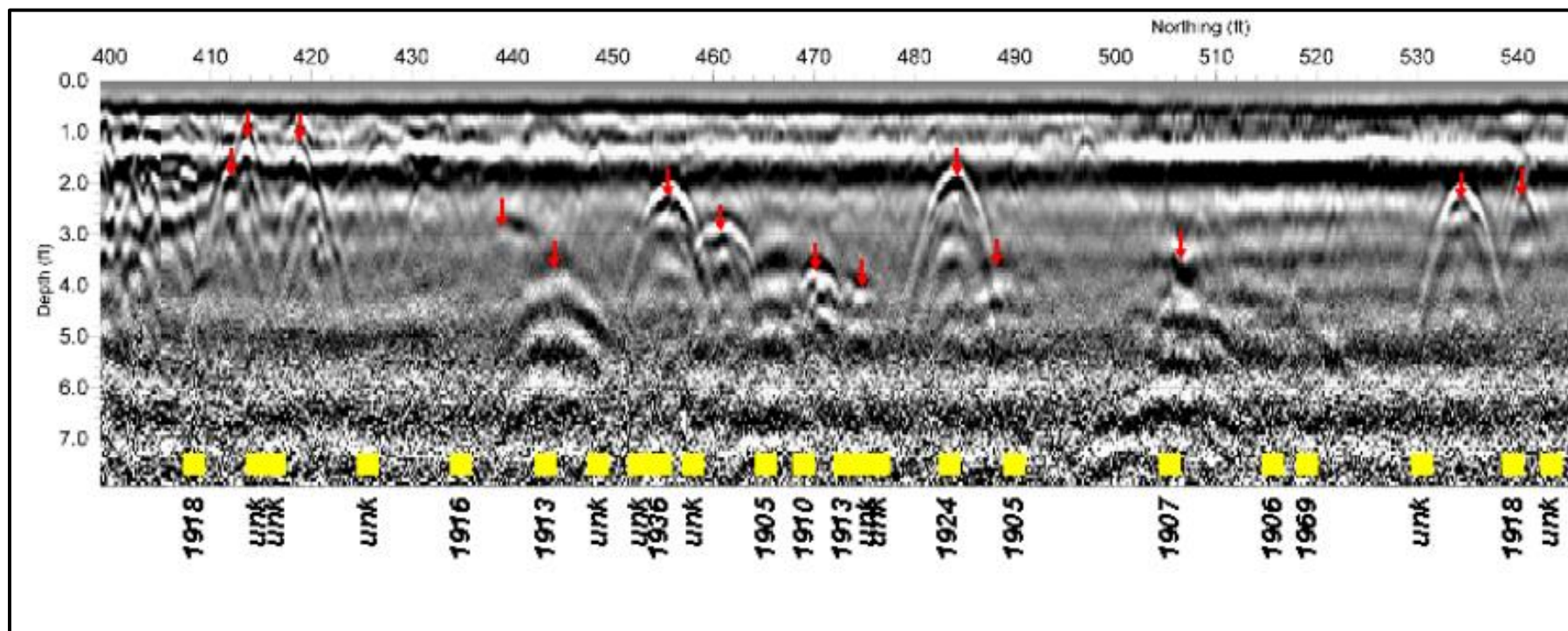


Figure 15: Excerpt from Radargram showing possible graves (Byer and Mundell 2003:9).

## **Historic Domestic Sites**

Domestic sites only comprised twenty percent of the geophysical surveys from SHAARD (2017). At some sites the original structures are still standing, but more often than not any physical evidence of the structure is no longer visible and the only indication of a structure having been there is reflected in sub-surface features.

### **Gordon Homestead, Spencer County, Indiana**

In 2009, Indiana University conducted an archaeological investigation on the Lincoln State Park for the Lincoln Bicentennial celebration. The multi-method geophysical survey was conducted on about 10,000 square meters of the park and focused on three early 1800s sites: the Colonel Jones' property, the Gordon homestead, and the supposed location of the Gordon horse-mill (Peterson et al. 2010:5). For this case study, I will focus on the survey and results of the Gordon homestead. Noah Gordon was a friend and neighbor to the Lincoln family when they lived in the area. The exact location of the homestead is unknown, as there are no remaining house structures, but the presence of a masonry well suggests the approximate location of the house (Peterson et al. 2010:68). The well and presumed location of the house are within a clearing, which was the location of the geophysical surveys. Peterson (2010) notes that the soil in that area was Zanesville silt loam, which is formed in silty loess material. Electrical resistance, magnetometry, and GPR were applied in grids of 20 by 20 meters and their locations were recorded using a handheld GPS unit. The electrical resistivity, or earth resistance, survey was conducted using a Geoscan RM15 meter with a twin-probe array. The probes were spaced 0.5 meters apart and readings were collected at 0.5 meter intervals (Peterson et al. 2010:74). The electrical resistance data were processed using Geoplot 3.00. The magnetometry survey was conducted using a Barrington Grad601-2 dual fluxgate gradiometer (Peterson et al. 2010:73).

Data were collected at 0.125 meter intervals with transects spaced 0.5 meters apart; the data were processed with Geoplot 3.00.

The magnetometer results showed that the strongest magnetic anomalies in the survey area were related to modern features that contained iron (Peterson et al. 2010:80). The strongest response was the modern iron cover of the well and a parallel pattern that is thought to indicate an iron pipeline. Another interesting anomaly detected by the magnetometer was an area with numerous magnetic anomalies, which is thought to indicate an area with historical human activity and consists of a series of discrete anomalies interpreted as being archaeological features and potentially the location of the Gordon cabin (Peterson et al. 2010:80-81).

Similar to the magnetometry results, the electrical resistance survey uncovered a number of anomalies of archaeological interest. The most interesting anomalies were those in the suggested location of the Gordon cabin and consisted of a rectilinear high resistance anomaly, thought to be the subsurface remains of the cabin, and an area within the rectilinear feature of slightly higher resistance, thought to potentially be a root cellar.

### **The Rankin House, Fort Wayne, Indiana**

In 2005, the Minihaha Foundation was contracted to conduct a GPR survey around the Rankin House, an 1840s historic house located in downtown Fort Wayne, Indiana (Weddell 2005:1). The landscape surrounding the Rankin House has experienced several drastic episodes of landscape change, including modern urban development, and pouring and laying of cement, asphalt, and/or brick. The only remaining part of the original yard is a small patch on the east side of the house (Weddell 2005:1). The GPR survey targeted the surrounding grounds and was conducted with a RAMAC 250 MHz antenna. While the 250MHz antenna does not produce very high resolution images, it does easily penetrate concrete and brick surfaces. After the 250 MHz

system was applied, the area was surveyed again with a 500 MHz antenna to collect higher resolution data for more refined images (Weddell 2005:1).

Because most of the surrounding landscape was disturbed by utility pipe installation, no formal grid was established. Instead, an area where it was thought utilities entered the north wall of the foundation was targeted for survey (Weddell 2005:2). East of the Rankin House was a sidewalk, where five radargrams spaced 0.5 meters apart were gathered. The most interesting area surveyed was the recent cement parking slab located on the west side of the house. A grid 4.5 meters by 7 meters was set up on the slab and surveyed. It was noted that neither the 250 MHz nor the 500 MHz radar signals had any issue penetrating the concrete slab (Weddell 2005:2). After processing, long parallel objects, oriented east-west and running the full width of the survey area were noted in the data. Due to the weak reflection strength of the signal, it is thought that these anomalies are not ferrous in nature. A possible explanation is that these features are septic tiles, floor joints, or possibly wooden beams (Weddell 2005:3).

### **Summary of Historic Domestic Sites**

The Rankin House was selected to be a case study because the goal of the survey was to observe the development of the house landscape, as is the goal of the Moore-Youse House survey. The purpose of the Rankin House survey was to locate any utility features associated with the house, so the researchers were looking for long, continuous anomalies that connected to the house in some manner. The researchers were aware the modern construction and development of the surrounding lawn might influence the results of the survey, such as with the recently poured concrete slab, but they incorporated that knowledge into their data analysis (Weddell 2005:3). With the analysis and interpretation of the concrete slab, the researchers had to take into consideration the development and modernization of the landscape up to the present

day, thus applying modernization theory. For the Moore-Youse House data analysis, I will incorporate my knowledge of the recent landscape history, such as the unit locations from the 2004 fieldschool, and look for any long, continuous anomalies that connect to the house.

The Gordon Homestead was selected as a case study because the purpose of the survey was to locate any possible foundation remains of the structure. In the survey, researchers were searching for areas of high activity or geometric patterns that provide an indication of the presence of the homestead. Peterson noted that there were multiple interesting anomalies present, including an area with variable readings thought to indicate historical activity (Peterson et al. 2010:80-81). This may also be the case for the work at McGowan Hall. Historic records indicate multiple events of landscape development, including the deconstruction of the mansion itself. The author expects to see a field of building debris in the GPR data for the mansion. Another interesting characteristic that Peterson observed was an anomaly that was rectilinear in nature with high resistance that is thought to be the subsurface remains of the cabin. An area within the rectilinear feature of slightly higher resistance was thought to potentially be a root cellar (Peterson et al. 2010:81). As with the Gordon Homestead, the author hopes to see the outline of the McGowan Hall foundation in the GPR data.

### **Specialty Sites and Modern Sites**

Since specialty sites, such as military sites for example, were specifically designed for typically one function, they provide a snapshot into that time period for that particular activity. Modern sites are those that have had any landscape development within the past 50 years and typically have recent construction or modern day utility lines. Since this thesis presents two specialty sites and one modern site (the Indianapolis Knights of Columbus McGowan Hall, the

Delaware County Orphans' Home, and the Eaton house) it was necessary to provide case studies of a specialty site and a modern site.

### **Harmonist Redware Kiln Site, New Harmony, Indiana**

The University of Southern Indiana conducted archaeological investigations in 2009, 2010, and 2012 at the Harmonist Redware Kiln site in New Harmony, Indiana. The Harmonists were a religious group from Germany that formed in the late eighteenth century (Strezewski 2013:xiv). In 1814, they moved from Germany to Posey County and formed New Harmony, along the Wabash River. New Harmony was occupied from 1814 to 1825 and contained 180 buildings holding an estimated 750 individuals (Strezewski 2013:xiv). The Harmonists produced a variety of goods for personal usage and for export, including redware pottery. A low-fired, lead glazed earthenware, the completed ceramic resembles a flowerpot in texture and density and was the most produced ceramic in the Midwest through the 1840s (Strezewski 2013:xiv). The location of the manufacturing site at New Harmony was identified using nineteenth century maps and geophysical survey.

The Harmonist Kiln site has experienced several seasons of archaeological excavation, which were conducted in 2009, 2010, and 2012 by the University of Southern Indiana (Strezewski 2013:xiv). A geophysical survey was conducted to locate deposits related to the Harmonist use of the site. A magnetic gradiometer was used to detect the brick from the kiln and firing of redware and a GPR unit was applied to complement the gradiometer (Strezewski 2013:43). The magnetometry survey was conducted using a Geoscan FM-256 fluxgate gradiometer with eight readings collected per meter along transects spaced at 0.5 meter intervals. The gradiometer survey was conducted in 2008, in proximity to the Harmonist kiln, and a total of eighteen 20x20 m grids, a combined 0.39 acres (3,195 square meters), was surveyed (Strezewski

2013:44). Field observations noted that while the survey area was mowed, several obstacles prevented certain areas from being surveyed. The magnetometry data was processed with Archeosurveyor 2.4.0.23. The GPR survey was smaller and was meant to target ‘hot spots’ identified by the magnetometry survey (Stezewski 2013:44). The GPR survey was done with a Geophysical Survey Systems SIR-3000 400 MHz antenna and data was collected from two grids covering 298.8 square meters (Stezewski 2013:45). The radar data were collected along north-south transects with a 0.5 meter spacing (Stezewski 2013:46). The GPR data was then processed in GPRSlice and three-dimensional images were created.

As expected, the magnetometry results from the location of the kiln located multiple targets. While most of the anomalies cannot be precisely identified, a high number of larger anomalies were examined and excavated in 2009 (Stezewski 2013:50). After the magnetometry survey and excavations had been completed, the GPR survey focused upon areas of greatest potential to help with the placement of future excavation units (Stezewski 2013:50). The results of the GPR survey generally matched with the results of the magnetometry survey, and also highlighted large anomalies and areas with highly reflective materials. While the GPR results provided more information about the locations of subsurface deposits, none of the anomalies held any particular shape nor were there clear structural outlines (Stezewski 2013:50).

### **Inter-Urban Line Site, Marion County, Indiana**

The Inter-Urban Line site was a ground penetrating radar survey that was conducted from August 30 to September 1, 2016. Brian Clem, from Blood Hound Inc., oversaw the survey of six locations on Virginia Ave, Shelby Street, Delaware Avenue, and parts of College Avenue in Indianapolis, Indiana (Stuehrenberg 2016:2). The purpose of the survey was to determine if there



were any remnants of the rail line track present under the modern road. The inter-urban rail line was closed for operation in either the late 1930s or the early 1940s (Stuehrenberg 2016:2).

Proposed construction may disturb extant rail remains and the survey was conducted to confirm the location of any remaining tracks. The survey was conducted with a Sensors and Software Noggin SmartCart, which held a 250 MHz antenna (Stuehrenberg 2016:2). All transects were gathered in a pattern that ran perpendicular to the original track locations; data were collected to a depth of 10 feet when the signal was sufficient to penetrate to that depth. The data were analyzed in real time and collected for further analysis and review (Stuehrenberg 2016:2).

The results from Virginia Ave showed reflections in the supposed locations of the former tracks at every location along the avenue. Locations 1 to 4 displayed evidence of only one set of tracks, while the survey in locations 5 and 6 showed two sets of tracks (Stuehrenberg 2016:3). On College Avenue, seven supposed locations of rail tracks were surveyed and at each location, two sets of anomalies thought to be tracks were present, except for one location on 66th Street. All observed anomalies were recorded in real time, measured, and marked on construction plans (Stuehrenberg 2016:3). Overall, the surveys were fairly successful with only one location not having any anomalies related to the rail tracks. All of the locations on College Avenue showed two sets of possible tracks still present and centered under the roadway. Virginia Avenue locations showed possible tracks with one set of tracks present in all locations south of the South/East Street intersection (Stuehrenberg 2016:3).

### **Summary of Specialty and Modern Sites**

The Harmonist Kiln site was selected as the specialty site because the site had a large scatter of brick material, similar to what might be present at the Orphans' Home site. The GPR survey was situated to cover the area of greatest potential and was conducted to get a better

understanding of the redware deposits and kiln waste located in proximity to the Lenz House (Strezewski 2013:50). The GPR located a large anomaly east and north of the house, with a series of reflective surfaces of a variety of shapes. To the north of the house was an area with the greatest reflection density as seen in Figure 16 (Strezewski 2015:50). In the data, the supposed distinctive reflections are brick material, the same type of material hoped to be present at the Orphans' Home site.

The Inter-Urban Line site was selected as the modern site because the Inter-Urban survey and the Eaton House survey are both looking for anomalies that are ferrous in nature and the intent was to show how metal displays in the GPR results. The Inter-Urban site was in a modern, urban setting, with the remains of the rail supposedly beneath a layer of concrete. Iron, specifically a large amount of it, will cause a large, easily discernable reflection in the data, as seen in Figure 17. These hyperbolas are what the author is hoping to see in the Eaton House data while looking for the septic line.

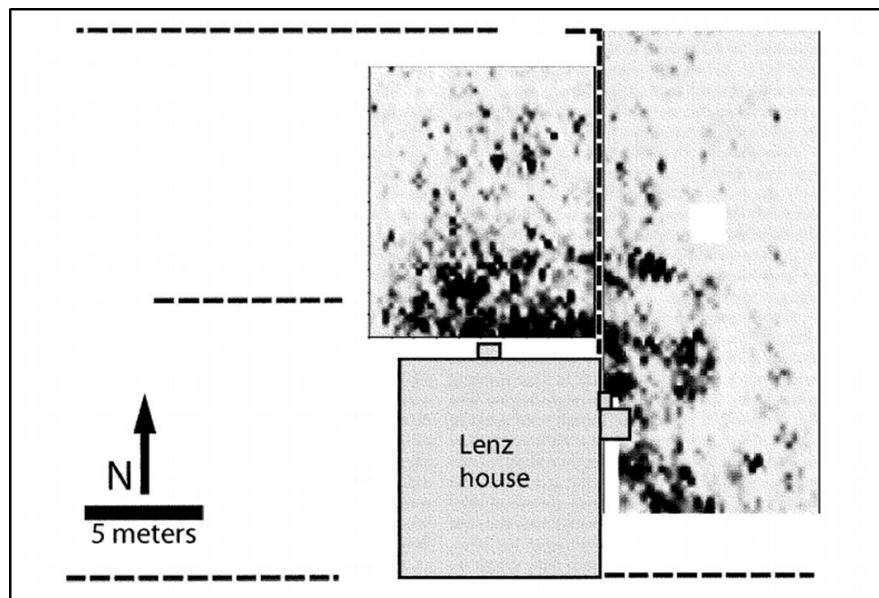


Figure 16: Ground Penetrating Radar Results from Harmonist Kiln Site (Strezewski 2015:51)

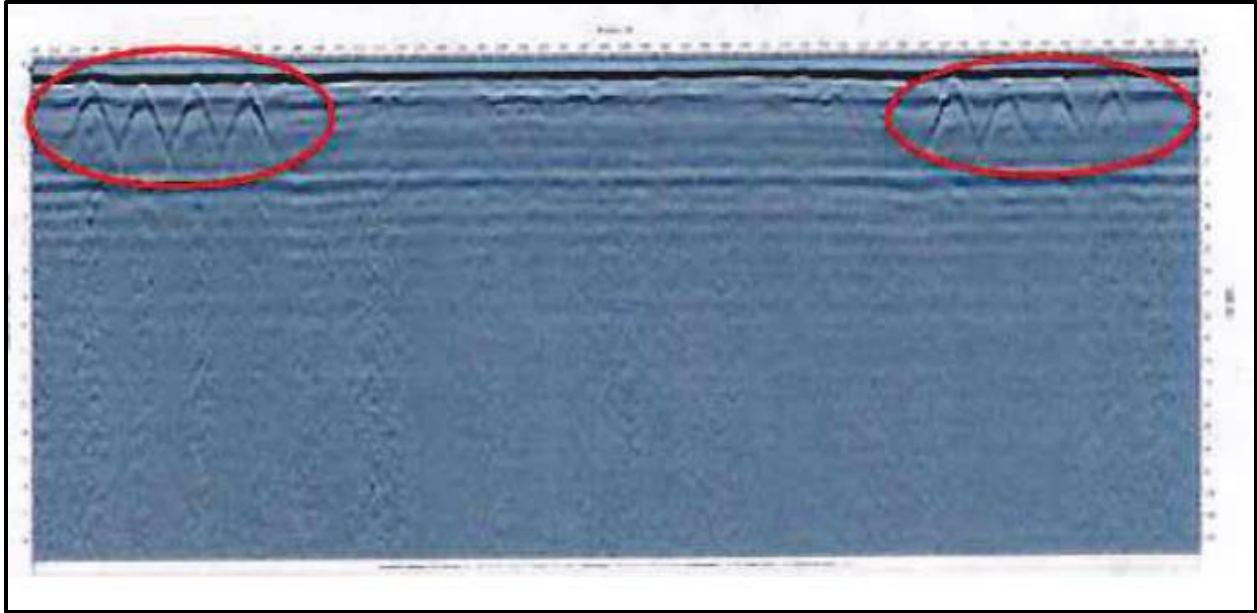


Figure 17: Intra-Urban Rail Anomalies from College Street (Struehrenberg 2016:3)

### Review

The case studies presented above illustrate the scope of geophysical work that has been done in the state of Indiana, while also providing a context for what characteristics other researchers are analyzing when doing anomaly identification. The other benefit of reviewing the case studies is that it provides insight into the methodology these researchers employed when conducting the survey and after, during anomaly identification. The Reese Cemetery survey and the Old City Graveyard survey both illustrate how the researchers identified gaps made in the soil stratigraphy as graves and grave shafts. The Gordon and Rankin House surveys illustrate how house foundations and remains appear as geometric features in the data, while the Harmonist Kiln site shows how a brick scatter appears in radar data. The Inter-Urban Line site demonstrates how modern metal appears in radargrams.

The case studies serve another purpose in that they demonstrate the application of landscape theory and modernization theory. Landscape theory was applied to the Gordon

Homestead, Rankin House, Harmonist Kiln site, and Inter-Urban Line site prior to survey to determine the most advantageous positioning of the survey grid. Historical maps and photos had been analyzed prior to survey to determine the possible locations of the features of interest and then the survey grid was oriented to catch as much of the features as possible. Because humans are always developing and expanding their landscape, many of the surveys noted the presence of modern features. Many archaeological surveys disregard modern anomalies, simply labeling them as modern. However, this thesis project attempts to identify as many anomalies as possible, including modern features. Modernization theory was applied to aid the identification of features, as well as organize the surveyed areas in a chronological order. In the case studies themselves, modernization theory was applied in the identification of the construction features at the Old City Graveyard site, the utility features at the Rankin House, and the rail features at the Inter-Urban Line site.

## **Chapter 3: Methodology**

Chapter 3 presents the methodology applied in this thesis project. This chapter is divided into eight sections: sections one through six discuss the process of site selection and survey application. Section seven discusses the processes and functions applied to analyze the GPR results and how the anomalies were organized for discussion. The final section provides a brief discussion of the 2017 National Park Service geophysical workshop.

The heterogeneity of the material world in archaeology means that the researchers must decide upon what perceptions and concepts they wish to focus on. While the topics and methodology for interpretation and analysis of the record are infinite, the archaeological record and database itself is finite (Shanks and Hodder 1995). For example, the researcher must decide what is to be measured, what aspects of artifact analysis can be focused upon and what aspects can be foregone, what position a farm held upon a landscape in relation to the natural surroundings, and so on. These are just a few of the decisions an archaeologist must consider when beginning preparations for research. Lines must be drawn to help focus, direct, and limit the scope of information that can be considered. For if there are no parameters, then the scope of the research will be too vast and the researcher will become misdirected from their original intention and focus.

### **Site Selection**

Since the purpose of this project was to create a reference guide, data were gathered from a wide range of site types that were historic and settler colonial. At the beginning, the goal was to have data for three domestic sites, four burial sites, and three specific activity sites, in order to have a substantial enough data set to provide a variety of site types and anomaly features. At the

completion of this project, a fourth site type, modern, was added to the classification. GPR data were gathered from two burial sites, two special activity sites, three domestic sites, and two industrial sites. After further consideration and per recommendation, the number of sites was cut down from ten sites to five sites: one cemetery, one domestic structure, two specialty structure, and one modern site.

There was also the distinction that had to be made between that of a clean site and that of a busy site. A clean site is a site in which there were very few other subsurface features than that of the projected features. A busy site is one in which there are multiple subsurface anomalies other than the projected features. While this consideration cannot be selected for, an attempt was made to target sites that may have had more than one period of occupation or use or had been destroyed and removed. Another consideration for site selection was location.

### **Locality**

Due to time and financial constraints, sites were selected from within Muncie, in Delaware County, Indiana. Sites surveyed outside of Muncie were linked to special projects conducted by the Department of Anthropology's Applied Anthropology Laboratories (AAL). The two sites surveyed outside of Muncie were the Indianapolis Knights of Columbus McGowan Hall, Indianapolis, Indiana and the Eaton House in Eaton, Indiana.

### **Survey Preparation**

As with all archaeological work, before any field work can take place, there are preliminary preparation steps that need to be taken in order to maximize available time and personnel for the survey. As mentioned previously, a list of sites was created and it was finalized when permission to survey was granted. All authorized parties were asked to sign and date a provided authorization form. The authorization form, drafted by the author and approved by the

committee chair, detailed the purpose of the project, briefly defined what GPR is, what actions would take place on the property, and provided a brief description of the analysis process and projected results. After the permission form had been signed by all proper authorities and returned to the author, communication was conducted by either email or phone to answer any questions or concerns and to coordinate the survey date.

### **Grid Preparation**

The results from the primary documentation analysis of maps, photos, and primary records assisted in the determination of grid orientation upon the site to be surveyed. The computer program used for interpretation, Radar Doppler Automatic Navigation, or RADAN, arranges data transects into four grid variations. Data files can be combined together to create a 3D grid file. Transects can be collected in the Y direction only, the X direction only, or both X and Y direction (GSSI 2012). RADAN automatically arranges the data files with the starting transect (Transect 0) in a southwest orientation. While this RADAN setting does not mean the grid cannot be set up in other ways in the field, it does require more time to be taken during data arrangement and analysis. Therefore, for time efficiency, field data were gathered with transect 0 beginning in the southwest corner of the grid and transects progressing northward. Other factors can influence and direct the arrangement of a grid upon a site landscape. Natural features (e.g., trees, shrubbery, etc.) and artificial features (e.g., artificial gardens, landscape walls, etc.) will dictate what can and cannot be surveyed by physically making it impossible to gather data efficiently in those locations. Consideration must be given on how to compensate for such features. Solutions for dealing with obstacles include ending a transect in front of the obstacle and starting a new transect on the opposite side. There will exist a gap in the generated 3D grid;

however, due to the orientation flexibility of RADAN, the user can manually set the beginning and end of a transect, thus determining the placement of transects upon the digital grid.

### **Grid Setup**

Grid setup is dependent upon the size of the area to be surveyed, what obstacles would impede upon a transect, and the orientation of the survey transects. For the purpose of efficiency, all grids were organized with transect 0 starting at the southwest corner of the grid and transects going in a northward trajectory. Transects were gathered with 0.5 meter spacing, while the size of the grid itself was subject to change dependent upon the size of the survey allowed by the site.

### **Field Crew Responsibilities**

While GPR setup and data collection can be completed by a single individual, all surveys conducted during this thesis project involved crews of two or more individuals. The two primary roles required for efficient GPR data collection are that of the GPR equipment operator and the note-taker. The role of the note-taker, while seemingly simplistic by description, involves more participation. The note-taker assists and participates in grid setup and orientation. Once the grid is set up and the data collection process has begun, the note-taker guides the GPR operator by standing at 0.5 meter increments; this ensures the data are collected in straight transects. The note-taker is also responsible for collaborating with the GPR operator to ensure that transects have not accidentally been skipped. The note-taker records any in-field, raw data interpretations the GPR operator makes. These notes are crucial later in the computer analysis process. For consistent note taking, a worksheet was created to improve the note taking process (See Appendix F).



The duties of the GPR operator require a more extensive knowledge of GPR analysis than that of the note-taker. The author was the sole operator of five surveys. For the other three surveys, the GPR equipment was operated by two or more individuals, under supervision of the author or other trained officials. The duties of the GPR operator begin with grid setup. After considering the features of the landscape, potential obstacles, and the surveyable area, the GPR operator determined, in consultation with the note-taker, the most optimal orientation and grid size for the grid. Once the grid was set up, the main responsibility of the GPR operator was to run the equipment. The GPR operator began at Transect 0 and progressed through all of the transects, completing the grid. While operating the equipment, the GPR operator was in constant communication with the note-taker, checking that no transects had been skipped and dictating any in-field observations for future analysis. The operator also made sure that transects started at the edges of the grid being surveyed

After the GPR survey was complete, GPS points were taken with a Trimble GeoXT handheld GPS unit. Trimble positions were recorded at all grid corners and any anomalies that were flagged while gathering data. The Trimble points are necessary to provide accurate coordinates in relation to known landmarks when the GPR 3D grid is geo-referenced in an ArcGIS map. Once all necessary Trimble points were taken, the grid was disassembled, flagged anomalies were marked with spray paint, flags were pulled, and the GPR equipment was disassembled and stored.

### **Post Processing**

Once the GPR data were gathered, they were transferred from the ESRI GPR computer to a computer with RADAN for data processing and interpretation. The data were arranged in the order transects were gathered, with Transect 0 beginning in the southwest corner. Once the

transects were arranged in their proper order, analysis could begin. Time zero, background removal, Finite Impulse Response (FIR), and migration were applied to all data sets for consistency. Deconvolution was applied if there were multiples present in the data from the signal bouncing back and forth between an object. The process of deconvolution improves the recognition and resolution of reflected events (GSSI 2012: 57). Other processes may be applied to the data to give it better clarity, but the previously mentioned four processing methods were consistently used across the data sets from the five sites presented here.

Data interpretation proceeded with a standardized analysis protocol. Both amplitude slices and profiles were analyzed. Analysis of the amplitude slices began with slices at 5 cm thickness and at 5 cm depth increments. After that, another set of thin (2.5 cm) and thick (10 cm) slices were examined to determine which thickness and increments were best for interpretation and presentation. Images of time slices were made at 10 cm depth increments, from the surface to 70 cm below the surface, and are displayed with a selection of radar profiles so that the reader can understand the shape of the anomaly in profile as well as plan view. Not all detected anomalies of potential importance appear in amplitude slice maps. Therefore, once analysis of the amplitude slices was complete, each radar profile was examined for subtle and distinctive anomalies. The horizontal locations of these were then marked on a plan map.

As mentioned before, GPR data differ from many other kinds of geophysical data in that it provides images at multiple depths. The detected anomalies differ electromagnetically from the surrounding soil. However, radar data does not tell you specifically what has been detected, just that there is a difference. While GPR may not be the most effective for differentiating the fundamental differences in specific site use (i.e., urban house from rural farm), it can be very effective for locating structures and detecting subsurface disturbances.

## **RADAN Processing Functions**

There are five basic RADAN processing tools that can be applied to GPR data. It is important to note that while all of these processes can be applied, they will not always be applied, as the purpose of RADAN is to enhance and present features. If the data has been gathered correctly, there should be very little RADAN processing required.

One of the first processes that can be applied is time zero. Time zero is when the first positive peak in the data is adjusted to be at the very top (GSSI 2012: 39). This takes into account uneven ground surface and allows for a more precise depth estimate. Finite Impulse Response (FIR) filter is a function that overlaps a finite length function, such as boxcar or triangle, with the GPR data. To apply an FIR filter, the user needs to set a high pass and a low pass. A high pass filter is “a filter that passes without significant attenuation frequencies above some cutoff frequency while attenuating lower frequencies. A low pass filter passes frequencies below some cutoff frequency while substantially attenuating higher frequencies” (GSSI 2012:40). Background removal subtracts an average scan, derived from a group (often a transect) of scans, from each individual scan in an effort to suppress background trends. The background removal tool primarily is used to remove horizontal trends from the data (GSSI 2012:40). Another important step in creating amplitude slice maps is migration. Migration adjusts the GPR data so that “...reflections and diffractions are plotted at the locations of the reflectors and diffracting points rather than with respect to observation points in the profile” (GSSI 2012:44).

Two other processing steps used in this study are range gain and block editing. Range gain adjusts the strength of the radar data, primarily as a way to make the weaker, deeper reflections appear as distinctly as the shallow reflections (GSSI 2012:54). Block editing simply

cuts off the bottom of the radar profiles. At many sites the radar profiles extend below the levels with detectable archaeology and the data collected from these depths was not needed.

### **Data Analysis Methodology**

In the site analysis discussion, “Class” is related to the number of defined anomalies versus the number of less defined anomalies. Class 1 sites have more “defined anomalies” than “less defined anomalies” and include anomalies that have either crisp, identifiable features or are in association with a known landscape feature (e.g., a rectangular sub-surface anomaly in proximity to a known archaeological test unit from a field school map). Class 2 sites have an equal number of defined versus less defined anomalies. Class 3 is when the number of defined anomalies is less than fifty percent of the less defined anomalies. The effectiveness of the GPR survey is determined by how clear subsurface anomalies are and how easily interpretable they are.

### **2017 NPS Geophysical Workshop**

As part of the process of completing this thesis’s goal of gaining experience in geophysical methods, the author attended the 2017 National Park Service Geophysical Workshop, hosted at the Pea Ridge National Battlefield in Pea Ridge, AK. Funding for this trip was provided by the 2017 IndianaView Student Scholarship and the Ball State University Research Foundation. The workshop, titled Current Archaeological Prospection Advances for Non-destructive Investigations of the Pea Ridge Civil War Battlefield, was held from May 15-19, 2017. There were five overall objectives for the workshop: (1) to become familiar with recent advancements in archaeological prospection techniques, their operation, and their application to archaeological survey and research, (2) to understand and appreciate the utility of advanced technological prospection techniques in the management of archaeological sites, (3) to

understand the strengths and limitations of each technique as applied to specific types of resources, (4) to understand the inter-relationship of the techniques to complementary data bases, and (5) to learn initial steps in processing and interpretation of data. There were additional objectives for the field application: (1) to observe the archaeological prospection equipment in use, and (2) to experience hands-on use of various types of equipment used in archaeological prospection. Lectures on the different geophysical methods were held in the morning from 8:00 AM to 12:00 PM, then from 1:00 PM to 5:00 PM field application of the learned geophysical methods occurred at the Pea Ridge National Battlefield. The surveys were conducted at Leetown and the investigations targeted areas to locate unmarked graves, remains of a Masonic Temple, house foundations, and a Civil War era road. Attendees then returned after dinner and from 7:00 PM to 9:00 PM instructors either presented recently gathered data or lectured. Twenty-six attendees and 15 instructors were present at the workshop and the topics covered included: LiDAR, aerial photography, metal detection, resistance/resistivity, magnetometry, magnetic susceptibility, and ground penetrating radar.

While attending the workshop, the author was able to receive formal lecture and field exposure to a variety of geophysical methods, network with professionals actively applying geophysics regularly to their research, and discuss thesis progress with a committee member. The formal lecture included the opportunity for the author to ask topic specific questions of experts about the survey method. After the lectures were completed in the morning, the workshop attendees meet in the field and applied the newly learned knowledge of the survey method in the field. The instructors were available to provide direction on how to use the method's instruments, which environments and conditions to apply the method, and how to best orient survey grids and gather data efficiently. In the evening, there was the opportunity to either

network or talk with the other instructors. On one evening, the author met with the third thesis committee member, Dr. Jarrod Burks, and took the opportunity to discuss GPR thesis results. On other evenings, the instructors would process the data gathered earlier and discuss their method of processing and interpretation.

## **Chapter 4: Results**

Chapter 4 consists of six sections. The first five sections present the results of the case studies conducted for this project. The case studies are presented in chronological order, starting with the earliest (Nottingham Cemetery) and ending with the latest (Eaton House). Each study discusses the site background, structural design, previous archaeological investigations conducted on site, the soils, the GPR survey methods, and then the results of the processing. After presenting the case studies, the final section discusses the effectiveness of the GPR at each site and ranks the case studies by Class 1, Class 2, or Class 3.

Five historic sites in Indiana were surveyed (Figure 18). For this thesis, sites have been assigned distinct names. Modernization theory was applied to identify modern anomalies and to analyze landscape development into the present. Landscape theory was used to analyze historic maps, historic terrestrial photographs, and aerials photographs, old and new, to determine how the sites were oriented on the landscape and how they may have influenced landscape development through human occupation. The sites surveyed include: the Delaware County Nottingham Cemetery (Nottingham Cemetery), the Moore-Youse Home Museum (Moore-Youse House), the Historic Minnetrista Complex Orphans' Home (Orphans' Home), the Eaton House, and the Indianapolis Knights of Columbus McGowan Hall (McGowan Hall). Of those five sites, four (Nottingham Cemetery, Moore-Youse House, Orphans' Home, and Eaton House) were located in Delaware County. Three sites (Nottingham Cemetery, Moore-Youse House, and Children's Home) were located in the city of Muncie, Indiana. One site (McGowan Hall) is located in Marion County. All surveys were done with a Geophysical Survey Systems Incorporated (GSSI) SIR-3000 system mounted on a three-wheeled carriage. The results of the surveys are discussed below.

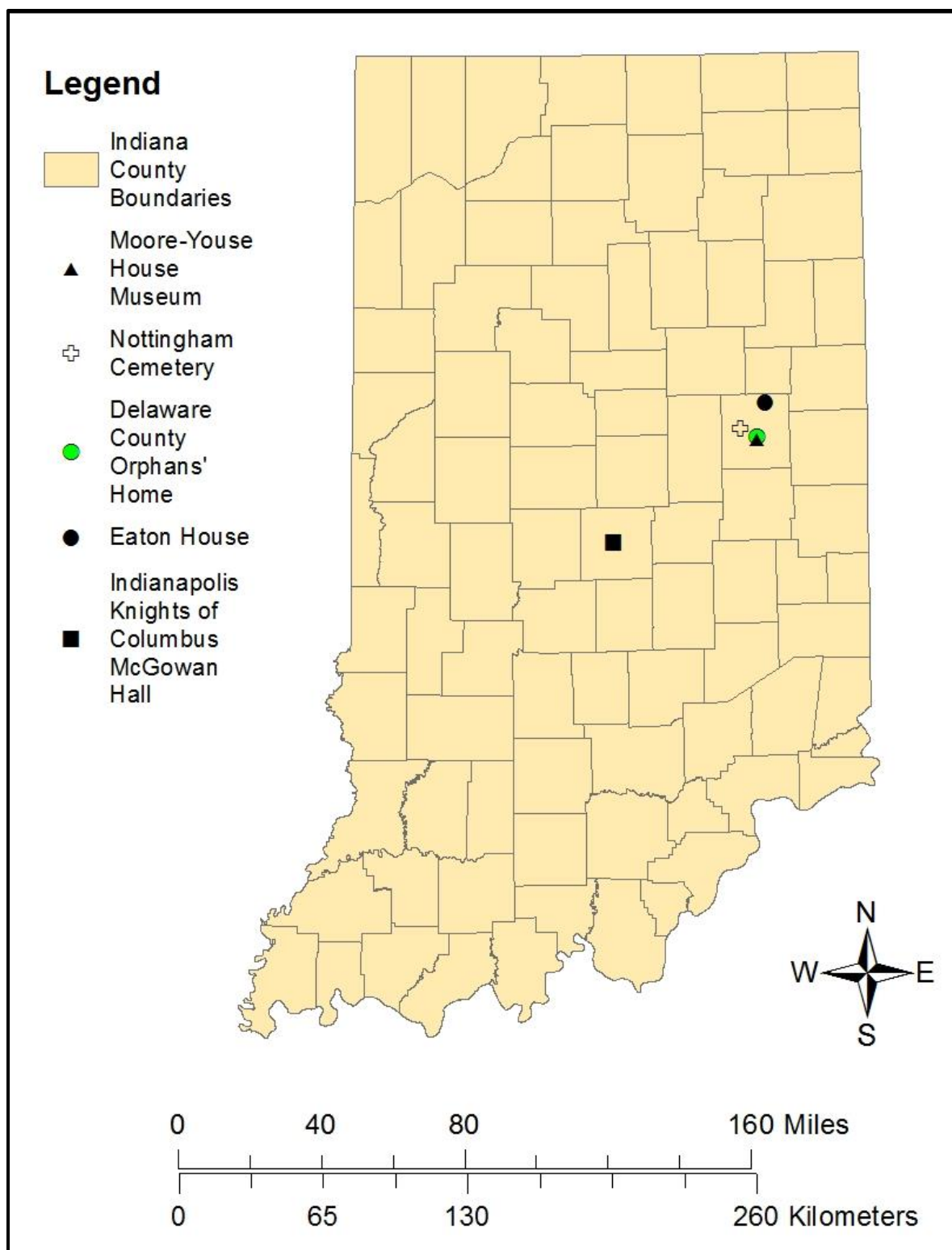


Figure 18: Surveyed Areas in Indiana.



## Nottingham Cemetery (1845-1909)

### Site Background

Located in Harrison Township, Nottingham Cemetery, also called Julian Cemetery, is five miles northwest of Muncie, Indiana off of Bethel Pike (Delaware County Historical Alliance 2016). It was originally called Julian Cemetery because it was located on Dr. Julian's Farm. Daniel and Amanda Tomlinson purchased 83 acres, which included the cemetery, in 1864 for a price of \$1600.00 (Delaware County Historic Alliance 1881). Though it does not provide information about the cemetery itself, the land deed mentions that there is a graveyard located in the southwest corner of the parcel.

*"The West half of the North-East quarter of the South West quarter of section Twenty-Six (26) and Three (3) acres off the North-West quarter of the South West quarter of section Twenty-Six (26) excepting however the grave yard in the South West corner of the land described, all of said land being in Township Twenty-One (21) North of range nine (9) East containing Twenty-three acres more or less. (Delaware County Historic Alliance 1881)*

The parcel was then sold again in 1868 to Elizabeth and William Nottingham for \$600.00. The exact timing of the shift to the name 'Nottingham Cemetery' is unknown, but it likely happened after Elizabeth and William purchased the land.

In 1991, two members of the Delaware County Historical Society visited all of the historical cemeteries within Delaware County and recorded headstone information, including name, row, dates (when available), and any other information on the headstones (Robert Good, personal communication 2016). The Delaware County Historical Alliance provided a copy of the documents recorded in 1991. The 1991 documents recorded 105 headstones, with the oldest belonging to Hiram L. Smith, who died in 1846; the most recent belonged to Wylie Earl Tuttle, who died in 1909 (see Table 15) (Delaware County Historical Alliance 2016). However, as is the case with many historical cemeteries prior to rescue by historical societies, the cemetery

experienced a period of deterioration, where headstones fell and broke. The cemetery came under the protection of the Delaware County Historical Alliance, which has done extensive work to preserve, reconstruct, and erect many of the headstones in the cemetery. The exact number of burials in Nottingham Cemetery is unknown, but there is an estimated 30 unmarked graves within its boundaries (Robert Good, personal communication 2016). The Nottingham Cemetery was surveyed in an attempt to locate unmarked graves and also to provide cemetery survey experience for the author.

### **Structural Design**

There are no physical standing structures located within the cemetery, the headstones are organized in the traditional manner, with headstones facing the east and organized in north-south rows. Headstones are spaced 1 to 1.5 meters apart.

### **Previous Archaeological Investigations**

Per Indiana's law and regulations IC 14-21-1, no activity which could have disturbed the ground has taken place since the last interment in 1903. No previous archaeological investigations were conducted on the cemetery.

### **Soils**

Soils were researched using the United States Department of Agriculture (USDA) soils survey and are displayed in Table 3. Nottingham Cemetery covers 0.5 acre and 100 percent of the soils in this area are classified as Glynwood silt loam (GlrB2) (USDA 2016).

Table 3: Soil Information for Nottingham Cemetery (USDA 2016).						
Type	Abbreviation	Landform	Material	Slope	Percentage of Parcel	Comments
Glynwood Silt Loam	GlrB2	Till plain	Moderately well drained loamy till derived from limestone and shale	1-4 %	100%	High runoff and eroded

Located on end and ground moraines within till plains, Glynwood soils have one to four percent slope and are considered prime farmland (USDA 2016). Moderately well-drained, the soil consists of rich, silty clay loam. While this material may be good for agriculture, it is poor for geophysical survey, as the presence of the clay and silt can interfere with and impede the radar signal.

Field notes taken during the survey recorded that there had been rain within two days of the survey and it was noted that the soil was still damp when the survey took place, which likely affected the outcome of the survey. The dielectric constant chart (Figure 8), created by the Geophysical Survey System Inc. (GSSI), indicates that clayey soil has a dielectric constant of 2.5, but with the presence of water, the dielectric constant is probably higher. The damp, clayey till certainly impacts signal attenuation and limits signal strength with depth, but it can also highlight features that disturb the till, such as grave shafts.

### **GPR Survey Methods**

The survey at Nottingham Cemetery was part of the 2016 GPR Workshop held by Dr. Kevin Nolan, Ball State University. The workshop was held on September 19, 21, and 26 and consisted of gathering and processing data. The first survey at Nottingham was conducted on September 19, 2016 by participants in the workshop, including the author. Field observations noted that there had been rain two days prior to survey and that the ground surface was damp during survey. The cemetery had been mowed recently and the only hindrances to the survey were the trees and headstones themselves (Figure 19).



Figure 19: Northwest Corner of Nottingham Grid, facing southwest (Photo by Amber Yuellig, 2016).

The intent of the survey was to target an area where there were unmarked graves. A 14 meter by 10 meter grid was established with a northern orientation in the south-east corner of the cemetery. The initial transects were gathered south-north along the Y-axis. A series of 10 additional radargrams were gathered along the X-axis traveling east-west, creating a crosshatch of transects. Data was gathered at a medium density, with transects spaced at 0.5 meter intervals and a total of 37 radargrams were collected. During processing, it was noted that the last seven radargrams collected were distorted. When the last seven transects were gathered, a crew member had received a phone call and that may have interfered with the radar signal.

The second survey was conducted on October 7<sup>th</sup>, 2017 and the field crew consisted of the author, Dr. Mark Groover, and Dr. Cailín Murray. Field conditions were more favorable and the ground was drier than the initial survey. The 400 MHz antenna was used and a dielectric constant of 14 was set for data collection. Fifty scans per meter were recorded along transects spaced at 50 cm intervals and to an estimated depth of 3.48 meters.

## **Results**

After data were gathered, they were transferred to and processed in RADAN 7. As noted previously, it is important to not over-process the data, which can sometimes filter out archaeological features or add new features. Three filters were applied to the Nottingham Cemetery data: block edit, time zero and FIR with a background removal. Time zero takes the first positive peak and adjusts it so that it is at the very top (GSSI 2015). This adjustment takes into account uneven ground and allows for a more precise depth estimate. The time zero correct was -2.15. The next process applied was FIR. Background removal was done simultaneously with the FIR filter, with a high pass of 195 and a low pass of 600.

Ten anomalies were identified in the processed data that are potentially grave related, including four possible unmarked graves (Table 4). Each anomaly was assigned a number and a description. Images of time slices were taken at 10 centimeter intervals with a 10 centimeter thickness and radargrams (profiles) were also created (see Appendix A: Figure 39 to Figure 47).

The ten anomalies are most evident in the radar data at 28 centimeters below ground surface (Figure 42). Six of the ten anomalies are approximately 1.5-2 meters (5-6.5 feet) in length. These anomalies are located along the western and northern boundary of the grid and field observations noted that there were standing headstones in that area. The anomalies of interest are the four smaller potential graves, located in the southeastern quadrant of the grid. These four potential graves are approximately one meter (3.28 feet) in length and are located in an area where there were no standing stones. Because of their size, these anomalies may be the unmarked graves of children.

Anomalies 1, 2, 3, and 4 may be graves. They appear as a line of hyperbolas between eight to ten centimeters deep, all are oriented east- west and between 1.5 meters to 2 meters in length (Figure 42 and Figure 48 to Figure 50). Anomalies 1, 2, and 3 are situated in the northeastern corner of the survey grid, along the western boundary of the survey area, with Anomaly 1 being the most northern anomaly. Anomalies 1 and 2 are spaced half a meter apart, while Anomalies 2 and 3 are spaced two meters apart. Anomalies 1, 2, and 3 are more than likely graves due to their proximity to standing headstones.

Anomaly 4 is the only likely grave anomaly not associated with a standing headstone, but it does display the same characteristics as Anomaly 1, 2, and 3, including a consecutive line of hyperbolas, gap in the natural stratigraphy, it is located eight centimeters below the ground surface, it is two meters long, and it is oriented east-west (Figure 42, Figure 53, and Figure 54).

Anomalies 5, 6, and 7 are all possible graves, as they are also a consecutive line of hyperbolas oriented east-west, are located ten to twelve centimeters below the ground surface, cause a gap in the stratigraphy, and are one and a half meters in length (Figure 50 and Figure 51). Anomalies 5, 6, and 7 are considered possible graves because they are very faint and do not have any association with a standing headstone. While Anomalies 5, 6, and 7 display similar characteristics to Anomalies 1, 2, 3, and 4, it is also possible Anomalies 5, 6, and 7 are tree roots. In GPR data, tree roots also appear as lines of hyperbolic features close to the surface and spanning several adjacent transects. This is a possibility, but since the location surveyed potentially contained unidentified burials, Anomalies 5, 6, and 7 were identified as possible graves.

Anomaly 8 is a combination of a series of highly reflective hyperbolas and a surface that are grouped together in the southeastern corner of the grid, seen in Figure 42. Similar to the other potential grave anomalies, Anomaly 8 is a series of hyperbolas that cluster as three 1.5 meter long graves at a depth of four to eight centimeters below surface. Anomaly 8 is also oriented east-west as graves typically are and could potentially be three graves next to one another. However, the surface is highly reflective, indicating the possible presence of gravel or metal.

Anomalies 9 and 10 are two highly reflective rectangular surfaces that are located just beneath the ground surface (Figure 39, Figure 51, and Figure 52). Because both surfaces are highly reflective, the material is probably either stone or metallic in nature. Anomaly 9 is one and a half meters long and half a meter wide, while Anomaly 10 is two meters long and a half meter wide. Based upon their rectangular nature and the reflective properties of the surface, Anomalies 9 and 10 could potentially be buried headstones.

Anomalies 11 and 12 are examples of the multiple, highly reflective points that occur throughout the survey grid. They are individual anomalies that are randomly scattered throughout the survey area and are concentrated within ten centimeters of the surface. A possible explanation for these individual anomalies is that they could be air voids from tunnels and holes created by burrowing animals.

While the saturated, clayey soil was a challenge for imaging possible graves, the results appear to show potential graves for ten individuals, four of them located in areas lacking markers. Since the purpose of the survey was to locate unmarked graves, this survey was a success. It also provided an opportunity for the workshop participants to obtain some field experience.



Table 4: Nottingham Cemetery Anomalies.		
Anomaly #	Depth	Description
Anomaly 1	8 cm	Anomaly 1 is Likely Grave 1 and is a line of four hyperbolas that is 2 meters in length. Anomaly 1 is in proximity to a headstone.
Anomaly 2	10 cm	Anomaly 2 is Likely Grave 2 and is two hyperbolas right on the western boundary of the grid going west. Anomaly 2 is in proximity to a headstone and is oriented east-west.
Anomaly 3	10 cm	Anomaly 3 is Likely Grave 3 and is a line of five hyperbolas that is 2.5 meters in length. Anomaly 3 is in proximity to a headstone and is oriented east-west.
Anomaly 4	8 cm	Anomaly 4 is Likely Grave 4 and is a line of four hyperbolas that is 2 meters in length and is oriented east-west.
Anomaly 5	12 cm	Anomaly 5 is Possible Grave 1 and is a line of three faint hyperbolas that create a small curve. Based upon the consistent depth of the hyperbolas, the east-west orientation, and that its length is 1.5 meters, it is possible that Anomaly 5 is a grave.
Anomaly 6	10 cm	Anomaly 6 is Possible Grave 2 and is a line of three faint hyperbolas that creates a small curve similar to Anomaly 6. Based upon its positioning, that it's oriented east-west, and length of 1.5 meters, it is possible that Anomaly 6 is a grave.
Anomaly 7	10 cm	Anomaly 7 is Possible Grave 3 and is a line of four hyperbolas that create a curve, similar to Anomalies 5 and 6. Considering that Anomaly 7 disrupts the stratigraphy and that it's oriented east-west, it is possible that Anomaly 7 is a grave.
Anomaly 8	4-8 cm	Anomaly 8 is a series of highly reflective hyperbolas and a surface that could potentially be three graves clumped together. The hyperbolas and surface are about one meter wide and 1.5 meters long combined and oriented east-west on the eastern boundary of the grid and cemetery.
Anomaly 9	0 cm	Anomaly 9 is a highly reflective surface that is located right under the ground surface and is 1.5 meters long and about half a meter wide. Based upon the reflective and rectangular nature of Anomaly 9, it is possible that Anomaly 9 is a buried headstone.
Anomaly 10	0 cm	Anomaly 10 is another highly reflective surface that is located right under the ground surface. Anomaly 10 is about 2 meters long and about half a meter wide. Similar to Anomaly 9, Anomaly 10 is reflective and rectangular in nature and is potentially a buried headstone.
Anomaly 11	0 cm	Anomaly 11 is one of many highly reflective hyperbolas that are just underneath the surface of the grid. Based upon the reflective nature of Anomaly 11, Anomaly 11 is probably a metallic object.
Anomaly 12	6 cm	Similar to Anomaly 11, Anomaly 12 is a highly reflective hyperbola and is probably a metallic object.

## **The Moore-Youse House (1859-1982)**

### **Site Background**

The Moore-Youse House (Figure 20) located at 122 East Washington Street, Muncie Indiana, was constructed circa 1859 and is now owned and cared for by the Delaware County Historical Society (DCHS). Prior to this it was occupied by various generations of the Moore, Youse, and Maxon extended family. In 1982, the home was transformed into a house museum showcasing Muncie history.

The house lot, located in the Boyce Block Historic District, is bounded by East Washington Street on the southern edge of the property, Mulberry Street on the eastern edge, and Gilbert Street on the northern edge (Historic Muncie 2012). Moore-Youse house was constructed on Lots 7 and 8 and was occupied by several people throughout the house's time as a residence. The Moore-Youse house is unique in that it stands on a double lot, while many of the surrounding houses occur on single lots (Figure 21). The increase in space left room for gardens and livestock to be kept on the property (Blanch 2006:57).

Garriott (1995) notes that a previous structure was located on the lot before the Moore-Youse house was constructed. However, it is unknown what type of house it was, but architectural remains recovered from the lot are typical of smaller buildings, such as a log cabin. Historical records indicated that the one-room structure occupied the lot between 1846 and 1850 (Garriott 1995).



Figure 20: The Moore-Youse House Museum (Delaware County Historical Society 2002)

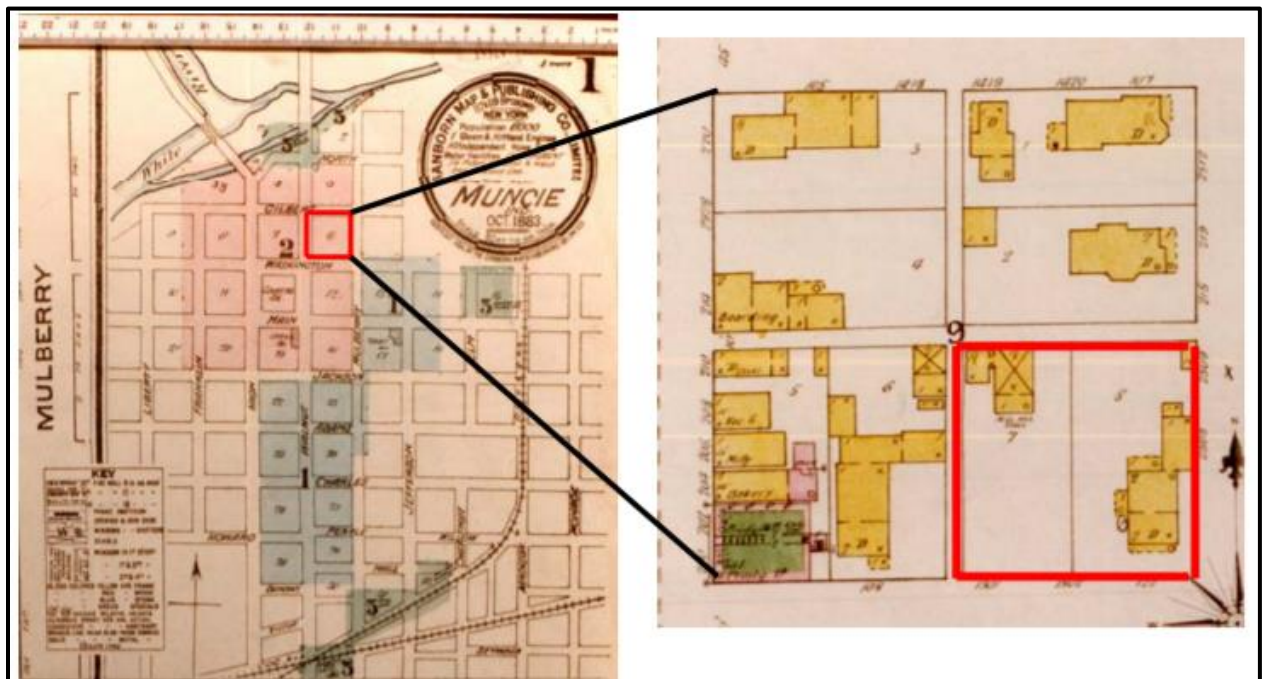


Figure 21: 1882 Plat Map of Muncie (left) and 1892 Sanborn Fire Insurance Map (right) Showing Location of Moore-Youse House. (BSU 1892).

## **Structural Design**

The Moore-Youse House is a Federal style two story structure with a side-gabled roof and an exterior chimney (McAlester 2015:224). In 1859, the house consisted of two rooms downstairs and two rooms upstairs, with the kitchen located on the main lower floor. In 1872, a one story addition was added to the back of the house and between 1872 and 1875 two more rooms were added, with one room having a door for external access (Blanch 2006:72). The front and side porches, seen in the image of the house, were added in 1887 (Blanch 2006:75).

## **Previous Archaeological Investigations**

The summer and fall of 2004, Dr. Mark Groover and several Ball State University archaeology students were invited by the Delaware County Historical Society (DCHS) to excavate in several targeted areas of the double lot (Blanch 2006:104). The primary purpose of the excavations was to establish and identify the surface distribution of artifacts associated with the household. By defining areas of low and high artifact density, it was possible to identify activity and landscape use of the lot. A series of shovel test pits (STPs) were established along the side of the lot (Figure 22). A grid of 120 feet by 90 feet was established at the southwest corner of the lot and STPs were excavated every ten feet (Groover 2004).

Shovel test pits were excavated in thin layers of 0.2 feet for better tracking of potential stratigraphy and the time of occupation. The use of thin levels allowed for time sequence analysis, a fine-grained method of stratification analysis developed by Dr. Groover, to be applied to the STPs (Groover 2004). The STPs encountered and recorded two areas of high artifact concentration. In total, 65 STPs were excavated and their historic artifacts identified. Several prehistoric artifacts were encountered as well.

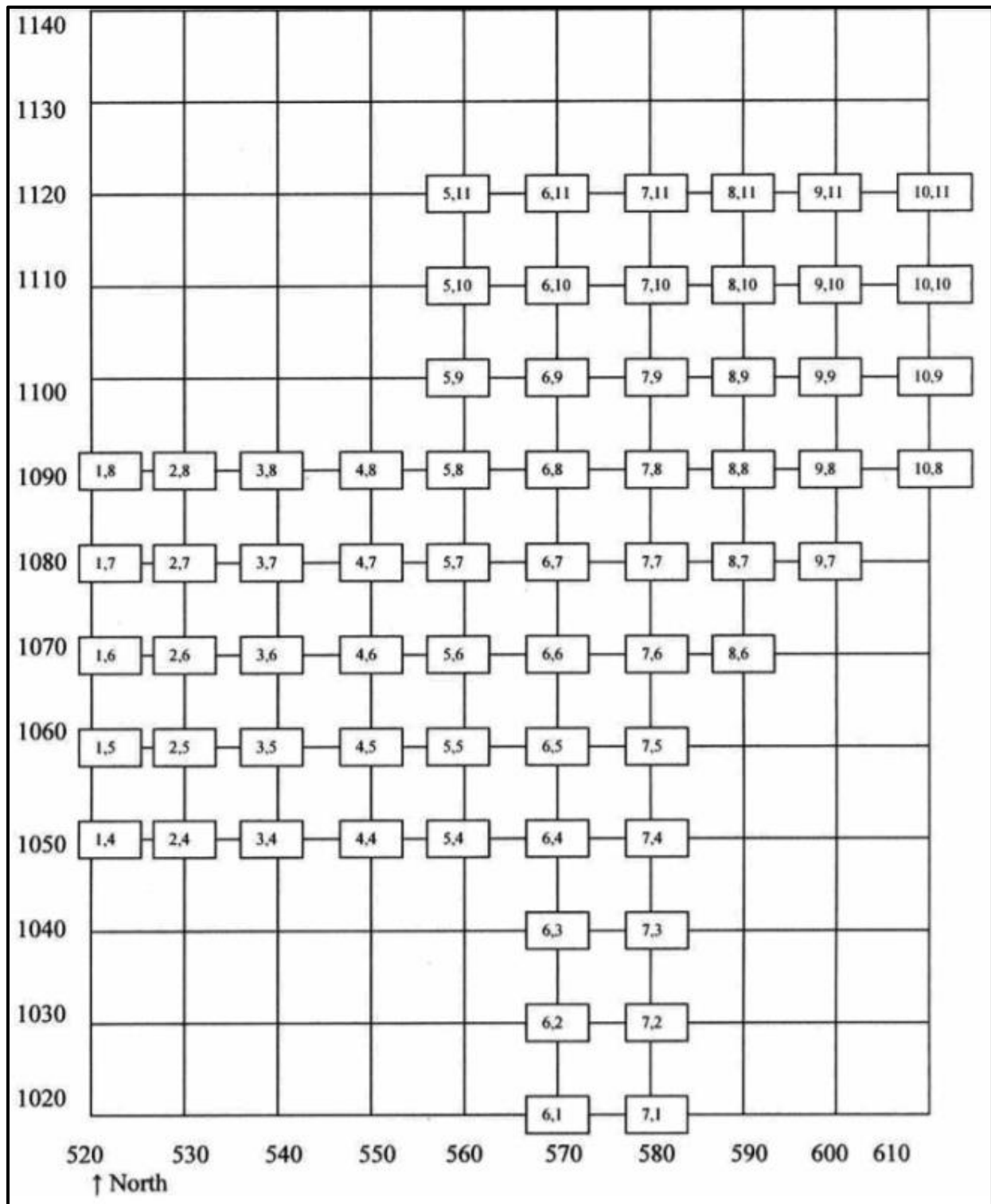


Figure 22: STP Grid Established at Moore-Youse house (Blanch 2006:107).

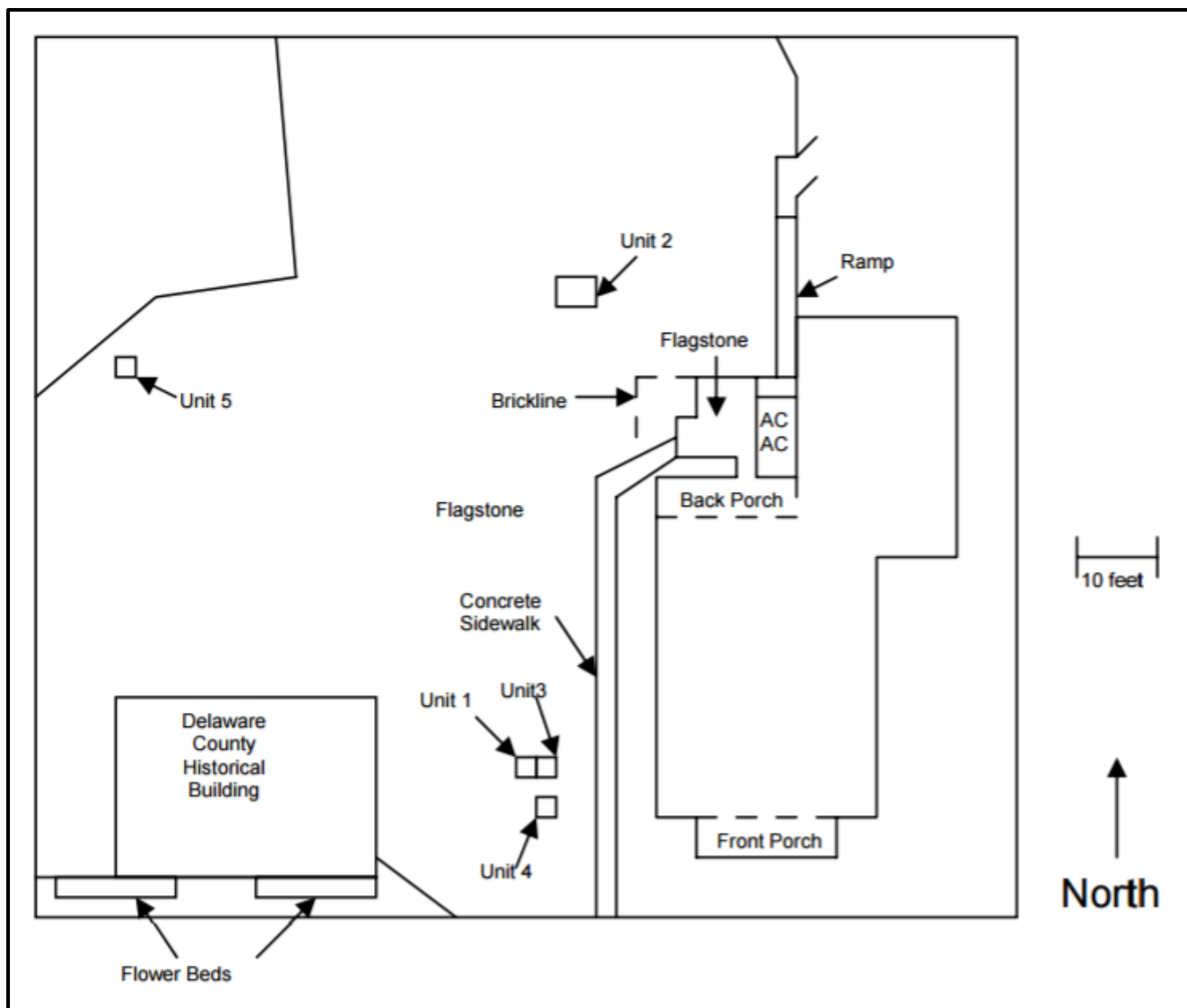


Figure 23: Basemap of Unit Excavations at Moore-Youse House. \*Due to distortion, scale of map is not accurate (Groover 2004).

The second part of the 2004 fieldwork at Moore-Youse house consisted of excavating a series of test units. Based upon the artifacts recovered from the STPs, five units were established to generate a finer grained analysis of the high artifact concentration areas (Figure 23). The purpose of the units was to help further identify architectural building episodes from the house and analyze the standard of living. Standard unit size was 3x3 foot units; however, one unit was 3x6 feet. Based upon artifact density and distribution gathered from the previous STPs, five units were excavated and the results further supported the findings from the STP excavations (Groover 2004).

### Soils

Soils were researched using the United States Department of Agriculture (USDA) soils survey and findings are displayed in Table 5. For the survey area of Lots 7 and 8, a total of 96.8 percent of soils discovered were Wawaka-Miami (UhaB) soil, while 1.6 percent of soils were Fox complex soils (USDA 2016).

Table 5: Soil Information from Moore-Youse House						
Type	Abbreviation	Landform	Material	Slope	Percentage of Parcel	Comments
Urban land-Wawaka-Miami	UhaB	Till plains on outwash plains	Loamy till over sandy and gravelly outwash	1-6 %	94%	Not prime farmland
Urban land-Fox complex	UemB	Terraces	Loamy outwash over sandy and gravelly outwash	1-6%	6%	Not prime farmland

Urban land-Wawaka-Miami soil consists of land covered by urbanization, such as streets, buildings, and parking lots that are superimposed on Wawaka and Miami soils. Wawaka-Miami (UhaB) is located on outwash-floored till plains with 1-6 percent slopes and is not prime farmland (USDA 2004). The soils are moderately well drained to well-drained and consist of loamy till over sandy and gravelly outwash.

Urban land-Fox complex (UemB) soils consist of urbanized land upon Fox soils. Located upon outwash terraces, Fox complex soils have 1-6 percent slopes and are not prime farmland (USDA 2016). Fox soils are well drained and consist of loamy outwash over sandy and gravelly outwash, similar to the Wawaka-Miami soils.

Field notes taken during the survey recorded that there had been no rain for two days and that the soil was dry, which is good for radar survey. The dielectric constant chart, created by the GSSI, indicates that the dry sandy soils have a higher dielectric constant than the dry sand and gravel, which the sandy soils rest upon. The dry, sandy loamy till has a dielectric constant of 6, while the sandy and gravelly outwash has a dielectric constant of 5.5. The radar energy waves will travel through the dry sandy soil faster than they will through the sand and gravel outwash.

### **GPR Survey Methods**

The Moore-Youse house was of interest for survey for future excavation work. Dr. Groover asked the author for survey to be conducted to support previous archaeological findings and to locate anomalies for potential future fieldwork. The Delaware County Historical Society was contacted and permission was granted for GPR survey. Once permission was granted, the survey team corresponded with the historical society to determine the date for survey. Sanborn fire insurance maps and plat maps were consulted to determine more efficient placement of the survey grid. Survey was conducted on October 24, 2016. Field observations noted that there had been no rain for two days prior to survey and that the area for survey had been recently mowed, with trees and a concrete plaque being the only obstacles to survey. A grid 8 meters by 24 meters was established with a northern orientation and transects were gathered south-north along the Y-axis. A dielectric constant of 14 was set and the unit gathered 50 scans per meter and 512 samples/scan to an estimated depth of 2.78 meters. Data was gathered at a medium density, with



transects spaced 0.5 meters apart for a total of 17 radargrams. The field crew was comprised of the author, Dr. Mark Groover, Dr. Cailín Murray, and Jessica Clark, a Ball State University anthropology graduate student (Figure 24).



Figure 24: Northeast Corner of Moore-Youse House Grid, Facing South (Photo by Dr. Murray 2016).

## Results

Two filters were applied to the Moore-Youse House data: time zero and FIR. The time zero correct had a time correction of -3.35. The next process applied was FIR. Background removal was done simultaneously with the FIR filter, with a high pass of 195 and a low pass of 595.

Once RADAN processing was complete, four anomalies were identified. Each anomaly was assigned a number, and a description was provided in Table 6. Images of time slices were made at 10-cm intervals from 10-70 cm below surface, with 20 centimeter thickness.

Radargrams (profiles) were also created (see Appendix B: Figure 55 to Figure 62).

Anomaly 1 is a surface feature that is 1.5 meters wide and is 10.5 meters long (Figure 56). It runs along the eastern grid boundary. Based upon the location and size of the anomaly, and observations of the ground in the field, Anomaly 1 is the sidewalk. The sidewalk begins from the street sidewalk and continues around the western side of the Moore-Youse House. Supportive evidence for Anomaly 1 being a sidewalk was the presence of small, evenly spaced hyperbolas that occur just beneath the sidewalk. These small anomalies are related to a wire mesh that was laid down before the concrete was poured on top.

Anomaly 2 is a linear cluster of hyperbolic points that is 0.2 meters wide, 8 meters long, and bisects the grid horizontally (Figure 57). The feature begins 7.58 meters north of the southern grid boundary and is highly reflective and crisp, indicative of it being metallic in nature. Anomaly 2 appears to connect the Moore-Youse House with the Delaware Historical Society headquarters, suggesting it is a utility line. Anomaly 3 is a rectangular surface one meter long and one meter wide, and it appears to be the location of a 2004 archaeological excavation unit Dr. Groover supervised (Figure 58). When compared against the 2004 basemap, it is suspected to

be Unit 4 (Groover 2004). Anomaly 4 is a surface that is one meter long by one meter wide (Figure 59). It begins 2.5 meters north of the southern grid boundary and is 4.5 meters north of the southern sidewalk. It may also be a 2004 excavation unit.

Table 6: Moore-Youse House Anomalies.		
Anomaly #	Depth	Description
Anomaly 1	0 cm	Anomaly 1 is a surface that is 1.5 meters wide and is 10.5 meters long. It runs along the eastern grid boundary and is associated with an existing sidewalk. The sidewalk begins from the street sidewalk and continues around the western side of the Moore-Youse House.
Anomaly 2	10 cm	Anomaly 2 is a line of hyperbolas, 0.2 meters wide, 8 meters long, and bisects the grid horizontally. The feature begins 7.58 meters north of the southern grid boundary and is highly reflective and crisp, indicative of it being metallic in nature. Anomaly 2 appears to connect the Moore-Youse House with the Delaware Historical Society Headquarters and is a utility line.
Anomaly 3	0-50 cm	Anomaly 3 is a filled in depression that is 2 meters long by 1 meter wide. The feature runs parallel to Anomaly 1, going north and is in the supposed location of the 2004 Unit 4.
Anomaly 4	0-45 cm	Anomaly 4 is a depression that is approximately 1 meter by 1 meter and square in nature. Suspected to be Unit 1 from the 2004 fieldwork.

While the GPR survey at the Moore-Youse House may have been unable to detect any midden features, the survey was very useful for showing the landscape development of that area. Anomalies 3 and 4 are potentially related to the 2004 archaeological excavations. Anomaly 1 is an indication of modernization and recent development in the landscape history. The process of using wire mesh in sidewalk construction is a modern technique, but is not an indication that the sidewalk placement is modern. A sidewalk may have led from the road to the side door during the Moore-Youse family occupation of the house, and it may have since been replaced. Finally, Anomaly 2, a utility line connecting the Moore-Youse House and the Delaware County Historical Society headquarters, is another indication of modernization and more than likely the most recent episode of landscape development for the Moore-Youse House.

## **McGowan Hall (1874-1963)**

### **Site Background**

McGowan Hall, originally referred to as the Bates House, was constructed in 1874 for Hervey Bates, Jr. and his family, and it was influenced by French architecture (Browne 2011). The Bates family lived in the house until it was sold to Elijah Martindale in 1880, who in turn sold it the following day to Dr. Horace and Harriet Allen (Browne 2011). The Allen's lived in the house until 1896 (Figure 25). While the Allen's resided in the house, they held many extravagant parties. The family left the house after one of the most devastating fires in Indianapolis history took place in 1892 at Dr. Allen's National Surgical Institute (Browne 2011).

The house was sold to David Parry and his wife in 1896 and during their residence at the hall, they changed the orientation of the driveway from the south to the north side and the hall's street address was changed (Browne 2011). David Parry and family sold the house in 1903 to the Hugh McGowan family. Hugh McGowan died in 1911 and Mrs. McGowan continued to live in the mansion until 1919, when the hall was purchased by the Indianapolis Chapter of the Knights of Columbus (KOC) (Browne 2011; Robert Newport, personal communication 2017). In 1922, the KOC constructed the clubhouse, seen in Figure 26, which still stands today, adjacent to the former location of McGowan Hall (Robert Newport, personal communication 2017).

Unfortunately, due to heating and maintenance costs, McGowan Hall was demolished in 1963 (Browne 2011). The 1922 clubhouse still stands and the remains of McGowan Hall are now covered by a parking lot (Figure 27)

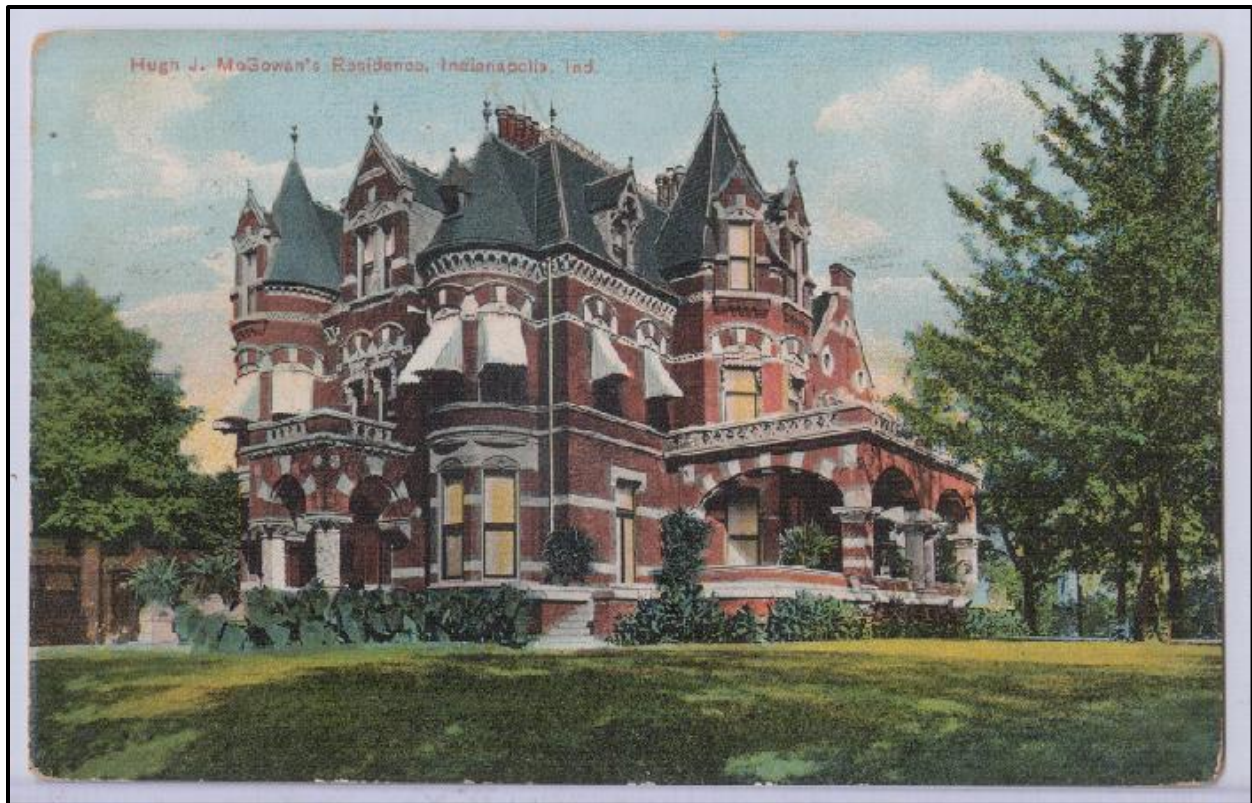


Figure 25: McGowan Hall Prior to 1896 (Browne 2011).

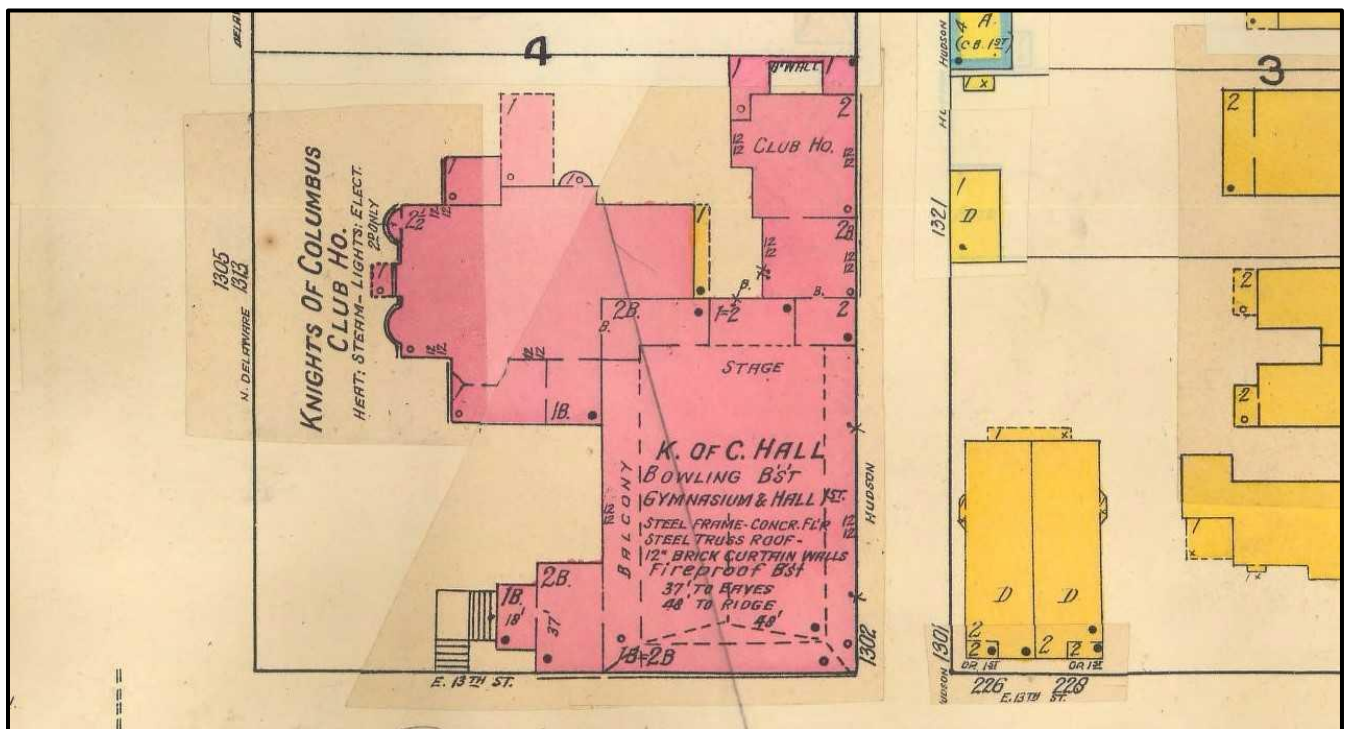


Figure 26: 1963 Fire Insurance Map (Newport 2016).





Figure 27: McGowan Hall circa 1922 (Browne 2011).

## **Structural Design**

The McGowan Hall building had four floors: the basement; a first floor which consisted of a drawing room, music room, billiard room, den, kitchen, and ballroom; a second floor that held the family rooms; and a third floor that most likely was used as storage (Robert Newport, personal communication 2017). The earliest photos of the house show a wood porch on the south side of the house, which had been removed by later photos (Figure 27). In 1922 an auditorium was connected to the building on the eastern side (Brown 2011). The hall is a style called Chateausque, with defining features such as steeply pitched roofs with heavily decorated spires, pinnacles, turrets, gables, and stylized chimneys. Multiple dormers and stone used for roofing were also common (McAlester 2015:469). Popularized by Richard Morris Hunt, the Chateausque style is a mixture of Gothic and Renaissance details and is prevalent from the 1880s to 1910 (McAlester 2015:469-450). McGowan Hall was styled with gables topped with steeply pitched roofs. The roofs were decorated with both intricate cresting and finials. The windows were decorated with hood molds and the roof line had detailed tracery (McAlester 2015: 470-471).

## **Previous Archaeological Investigations**

While there has been no previous archaeological investigation at the Knights of Columbus, the surrounding landscape has experienced the effects of modernization. The grassy front and side yards, seen in Figure 27 were leveled, graded, and then paved to create a parking lot.

## Soils

The city block containing McGowan Hall and the current KOC clubhouse stands on one acre and is covered by 100 percent Urban land-Fox Complex (UfA) soils (Table 7) (USDA 2016).

Table 7: Soil Information for McGowan Hall.						
Type	Abbreviation	Landform	Material	Slope	Percentage of Parcel	Comments
Urban land-Fox Complex	UfA	Terraces	Loamy outwash over sandy and gravelly outwash	0-3%	100%	Well-drained

Urban land-Fox Complex soil consists of land covered by urbanization, such as streets, buildings, and parking lots. Located upon outwash terraces, Fox complex soils have 1-6 percent slopes and are not prime farmland (USDA 2016). The soil is well drained and consists of loamy outwash over sandy and gravelly outwash.

Field notes taken during the survey recorded that there had been no rain for five days before the survey and that the soil and parking lot were dry, which are good conditions for GPR survey. However, all historical cultural remains were underneath a concrete parking lot, with the cultural remains themselves consisting of an assortment of construction materials, such as brick and metal. The parking lot cover has likely kept the buried remains of McGowan Hall fairly dry, except for ground water. The dielectric constant chart indicates that the dry sandy soils have a higher dielectric constant than the dry sand and gravel, which the sandy soils rest upon. The dry sandy loamy till has a dielectric constant of 6, while the sandy and gravelly outwash has a dielectric constant of 5.5. The radar energy waves will travel through the dry sandy soil faster than they will through the sand and gravel outwash.





Figure 28: Northwest Corner of McGowan Mansion Grid, Facing South (Photo by Amanda Balough, 2016).

## **GPR Survey Methods**

Survey at the Indianapolis Knights of Columbus McGowan Hall site was conducted on June 25, 2016. The goal of the survey was to search for any possible foundations from the 1874 mansion. A 25 meter by 30 meter grid was established with an eastern orientation and transects were gathered west-east along the X-axis. The grid was located north and northwest of McGowan Hall and positioned to cover the area originally occupied by McGowan Mansion (Figure 28). Data were gathered at a medium density, with transects spaced at 0.5 meter intervals; a total of 63 radargrams were collected. A dielectric constant of 6 was set and the radar system gathered 50 scans per meter to an estimated depth of 3.33 meters. The first dataset was completed with the 400 MHz antenna. An attempt was made to use the 200 MHz antenna, which is capable of detecting features to a depth of 15 m depending on soil conductivity, but due to technical difficulties and time constraints the attempt was abandoned. The field crew consisted of the author, Dr. Kevin Nolan, and Dr. Homes Hogue.

## **Results**

After the data was gathered, it was transferred to and processed in RADAN 7. Two filters were applied to the McGowan Hall data: time zero and FIR. A time zero correction of -0.21 was applied. Background removal was done simultaneously with the FIR filter, with a high pass of 195 and a low pass of 605.

Once RADAN processing was complete, four anomalies were identified in the data. Each anomaly was assigned a number and a description is provided in Table 8. Images of time slices were created at 15 centimeter intervals with 15 centimeter thickness and radargrams (profiles) were also created (See Appendix B: Figure 65 to Figure 73).

Anomaly 1 starts to become visible at 37 cm below the surface, but is most distinctive at 75 centimeters (Figure 70: McGowan Hall 75 CM with Anomaly 1 (blue). It is a series of hyperbolas and surfaces that are the remains of the McGowan Hall foundation after the house was demolished in 1963. At 72 centimeters below ground surface, Anomaly 1 is so crisp and defined that the curved edges of two of the towers are still distinct.

Anomaly 2, located on the northern boundary of the grid, is a highly reflective surface that is 4 meters wide and 26 meters long (Figure 66 to Figure 72). Anomaly 2, first visible at 20 centimeters down, may be the driveway after it was changed in 1896. Anomaly 3 is a depression anomaly that is 5.7 meters wide and 3 meters long. It is located one meter west of the north-eastern grid corner (Figure 66 and Figure 67). It is located 5 centimeters below the surface and goes down to a depth of 44 centimeters with a circular plan. Unfortunately, none of the Sanborn or historic maps provide an explanation for Anomaly 3. Anomaly 4 includes various highly reflective points which can be seen from the ground surface to 28 centimeters below ground surface.

Table 8: McGowan Hall Anomalies.		
Anomaly #	Depth	Description
Anomaly 1	37-134 cm	Anomaly 1 is a series of hyperbolas and surfaces that is the foundational remains of the McGowan Hall. Best seen at 75 cm down.
Anomaly 2	20-40 cm	Anomaly 2 is a surface that is 4 meters wide and 26 meters long and follows the northern boundary of the survey grid. It is highly reflective and causes a very deep echo. Potentially path beneath the concrete.
Anomaly 3	5-44 cm	Anomaly 3 is a surface-type anomaly that is 5.7 meters long and is 3 meters wide. Located approximately one meter west from the north-eastern grid corner.
Anomaly 4	Various	Anomaly 4 includes various square, highly reflective surfaces that are potentially metallic.

The survey of McGowan Hall was successful in that it was able to detect the building foundation. While the Sanborns and historic maps did not provide an explanation for all anomalies, the position of anomalies allows for insight into landscape development. Based upon positioning, Anomaly 1 is the oldest anomaly and was built in 1874. The next modern development was the installment of Anomaly 2, the driveway, which took place in 1896. The next event was the installment of Anomaly 3, which happened from 1896 to 1963 when the Hall was demolished. Anomaly 4 is the result of this demolition, as Anomaly 4 likely is debris.

## **Delaware County Orphans' Home (1890-1905)**

### **Site Background**

The Orphans' Home, displayed in Figure 29 , was constructed in 1890 and stood on the west side of Walnut Street in Muncie, Indiana, north of the White River, on what is now part of the Minnetrista Cultural Center property (Pearson 2012). The Delaware County Orphans' Home, as it was called, was a four story brick construction with two associated outbuildings that were occupied for 16 years, until the Orphans' Home was relocated and the two outbuildings were torn down (Haimbaugh 1924; Pearson 2012). According to articles from the Muncie Daily Times and the Muncie Evening Press, from 1890 to 1906, anywhere between twenty to thirty-two children were housed at the Orphans' Home (Pearson 2012). An orchard was planted and the children were given the responsibility of caring for trees, as well as selling the fruit (Vincent 2014). After the orphanage was relocated, the Ball Family purchased the property; they maintained and added to the orchard (Vincent 2014).



Figure 29: The Orphans' Home, circa 1890, Facing North (The Muncie Star 1993).



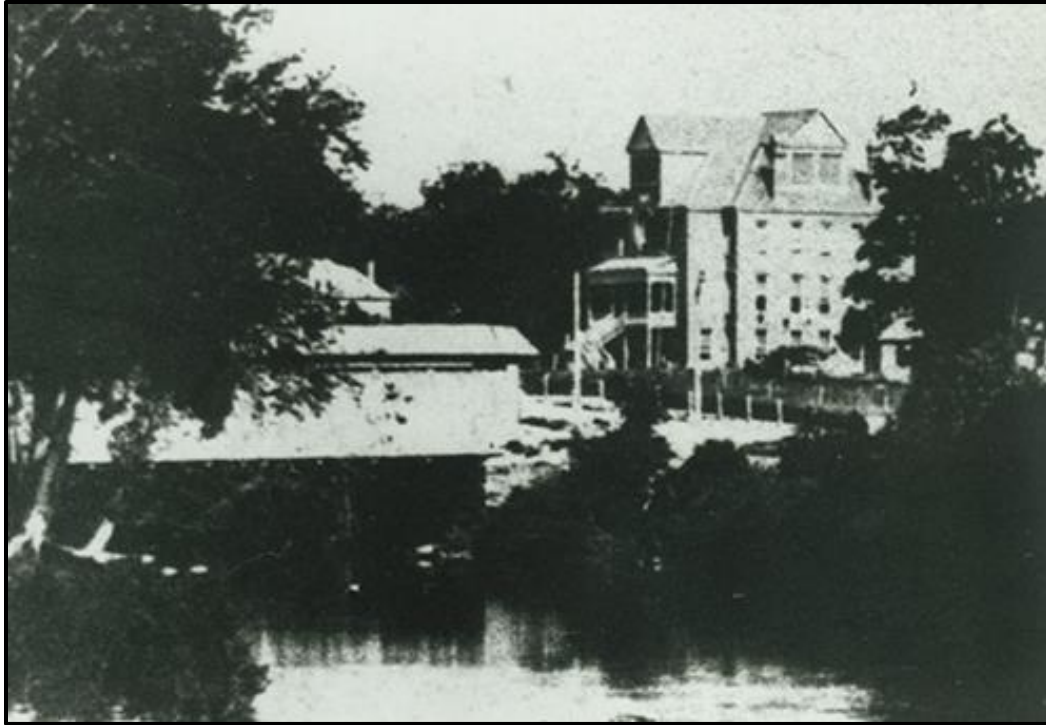


Figure 30: The Orphans' Home, Unknown Time, Facing West (Vincent 2012).

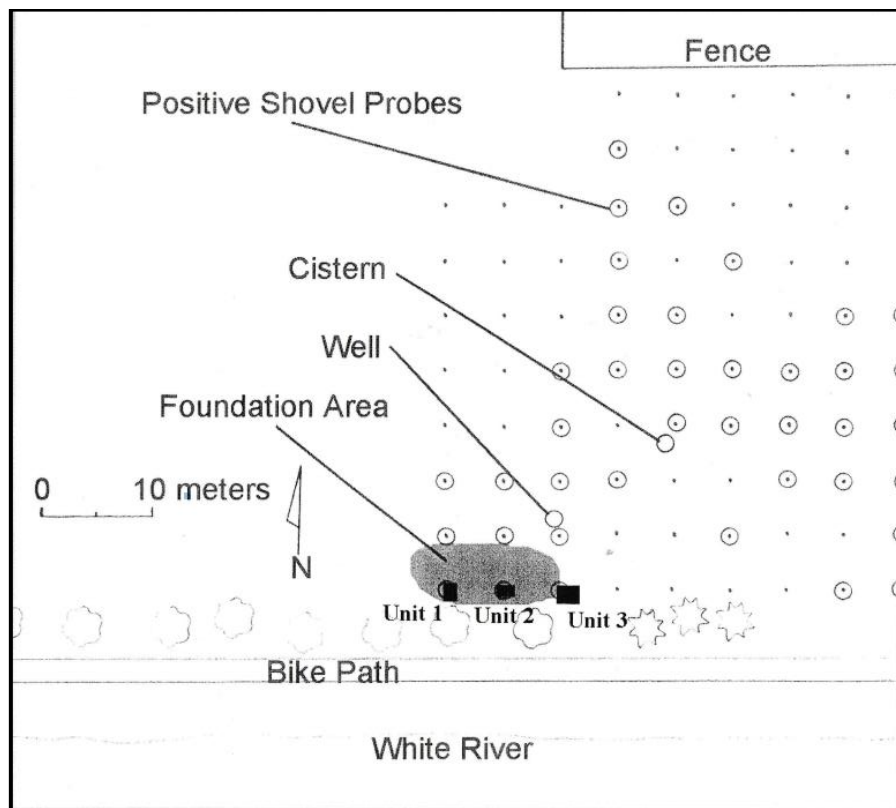


Figure 31: 2000 Archaeology Excavation Base Map, Facing North (Zoll 2001).

## **Structural Design**

The Orphans' Home is a Colonial Revival style five story structure with a side-gabled roof, one entrance on the east side of the building, and a grander entrance facing south towards the river (McAlester 2015:410). Photographs of the structure reveal it was minimalist in style, lacking shutters and window decorations typical of the style, but compensated by the detail put into the design of the southern entrance (Figure 29 and Figure 30). The southern entrance led into the second floor, with a faired porch and circular window adorning the southern façade. The side-gabled roof had two chimneys on the western side and one large dormer window on the eastern side.

## **Previous Archaeological Investigations**

In 2000, a Public Archaeology Project was conducted by the Minnetrista Cultural Center and the Archaeological Resources Management Service at Ball State University. The goal of the project was to educate the public about archaeology, but it also attempted to locate the remains of the Orphans' Home (Zoll 2001). Three test units were excavated over the course of 45 days and the public was invited to participate. The placement of the units was determined by the results from a 1999 shovel probe survey (Figure 30), which found a possible foundation, a well, and a cistern located on the East Lawn. The possible foundation remains were thought to be associated with the Orphans' Home (Zoll 2001). The three excavation units were oriented to hopefully catch the edges or corners of the foundation. The units measured two meters by two meters and were excavated in 10 cm intervals; all removed material was screened through ¼ inch wire mesh (Zoll 2001). While the excavations recovered 466 historic artifacts and 107 prehistoric artifacts, no foundations were uncovered.

In 2001, a second Public Archaeology Project was held on the East lawn of Minnetrista. The goal once again was to locate remains of the Orphans' Home foundation (Zoll 2003). The three original units were re-excavated and taken down more in an attempt to see if any structural remains were located deeper down. Again, all material removed from the units was screened through a ¼ inch mesh. Artifacts recovered from Unit 3 included scattered brick, limestone, and fire-cracked rock (Zoll 2003). Unfortunately, none of the brick or limestone, which were relatively scarce, appeared to be related to construction.

### Soils

The East Lawn, which is east of the Minnetrista Interpretive Center, is five acres of maintained land and a 100 percent of soils discovered were Urban land-Glynwood (EutB) (Table 9) (USDA 2016).

Table 9: Soil Information for Orphans' Home (USDA 2016).						
Type	Abbreviation	Landform	Material	Slope	Percentage of Parcel	Comments
Urban Land-Glynwood	UetB	Till plain	Loess over clayey till	2-6%	100%	Moderately well-drained

Urban land-Glynwood soil consists of land covered by urbanization, such as streets, buildings, and parking lots. Urban land-Glynwood (UetB) is located on till plain, with 2-6 percent slope (USDA 2004). The soil is moderately well drained and consists of loess over clayey till.

Field notes taken during the survey recorded that there had been rain two days prior to the survey and that the soil was damp. The damp clay till will greatly impact the signal strength and



block the signal, preventing it from traveling as far as it normally would and obstructing fainter signals. The dielectric constant chart indicates that clayey soil has a dielectric constant of 2.5.

### **GPR Survey Methods**

The Minnetrista Historic Complex was contacted and permission was granted for ground penetrating radar (GPR) survey to be conducted on site. The focus of the survey was to test areas of interest and potentially locate foundations of the Orphans' Home or the northern outbuilding. Sanborn maps and plat maps were consulted to identify a good location for the survey grid. An 1896 Sanborn map shows the outline of the Orphans' Home, circled in red in Figure 32, along with two outbuildings situated north of the Orphans' Home. One of the outbuildings can be seen in Figure 29 in close proximity to the Orphans' Home and it appears to be a laundry building. However, due to the organization of the streets and landscape features, the Sanborn map cannot be accurately georeferenced to reflect the original orientation of the Orphans' Home. A later 1955 Sanborn map confirms the destruction of the Orphans' Home and its disappearance from the Minnetrista East Lawn (Figure 33); it also shows the absence of the associated outbuildings. While the Sanborn maps and historic photos (Figure 29 and Figure 30) provide information on the shape and size of the Orphans' Home and surrounding structures, they lack enough spatial detail to pinpoint the foundations on today's landscape.

Google Earth historic aerials were referenced to see if any foundation structures were reflected in vegetation growth patterns. Figure 34 displays the 1992 vegetation patterns and the western edge of the square is still visible in the 2016 Google Earth aerial (Figure 35). The vegetation patterns in the 1992 aerial have the potential to be the foundation outline of the Orphans' Home. Another feature of interest is a potential road feature, visible in the 1992 aerial and more distinct in the 2016 Google Earth aerial. This road feature potentially led from North

Walnut Street to the Orphans' Home. Based upon the vegetation pattern, a grid was established to overlap the northwestern corner of the vegetation pattern representing the possible building remains.

The survey was conducted on October 24, 2016. Field observations noted that there had been rain two days prior to survey and that the topsoil was damp. The area for survey had been recently mowed and was clear of any obstacle. A grid 10 meters by 9.75 meters was established with a northern orientation and transects being gathered south-north along the Y-axis (Figure 36). A dielectric constant of 10 was set and the unit gathered 50 scans per meter to an estimated depth of 4.44 meters. Data was gathered at a high density in one direction, with transects spaced 0.25 meters apart and a total of 40 radargrams were collected. The field crew consisted of the author and Dr. Mark Groover.

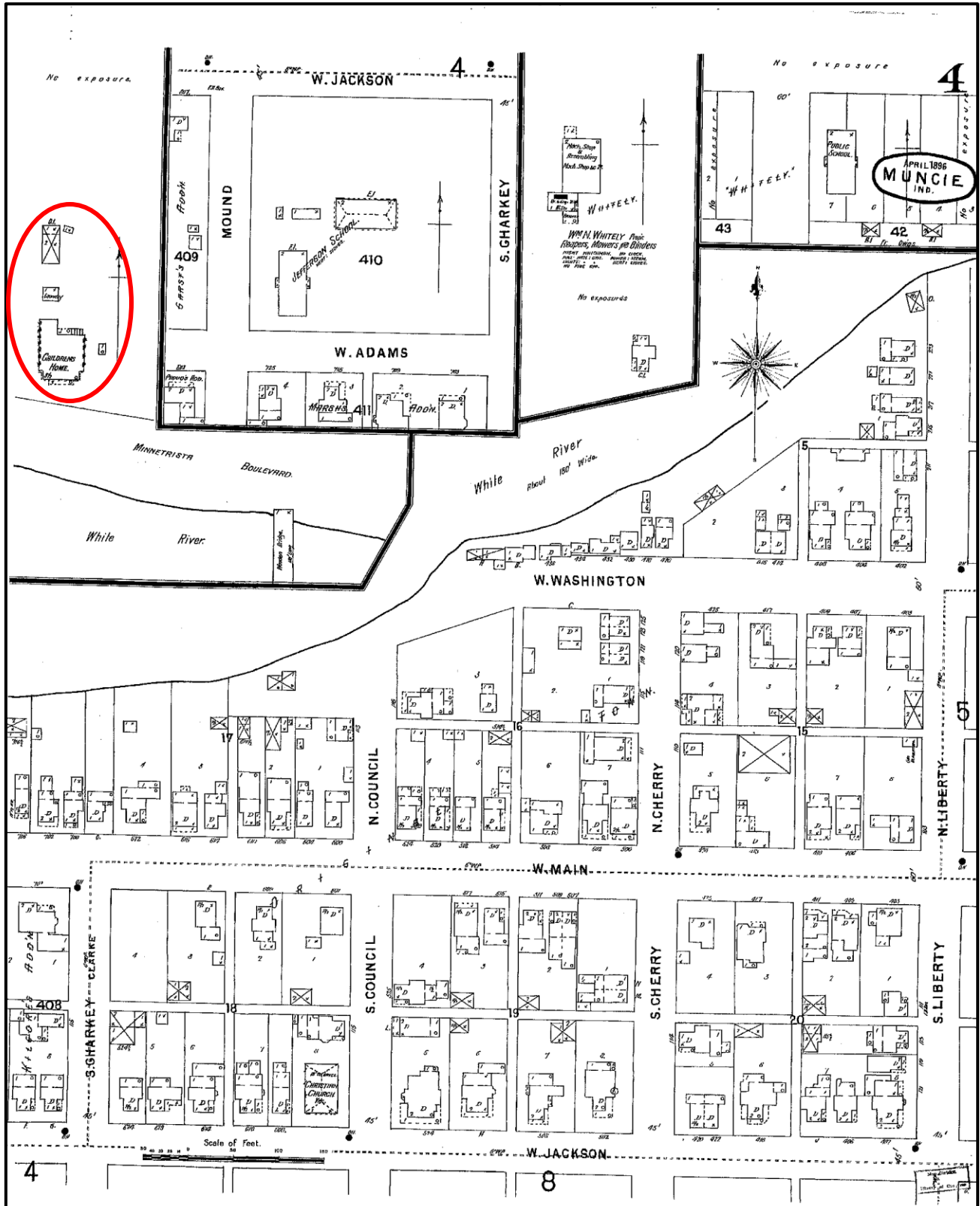


Figure 32: 1896 Sanborn Map of Minnetrista East Lawn with Childrens Home (IU Spatial Portal 2017).

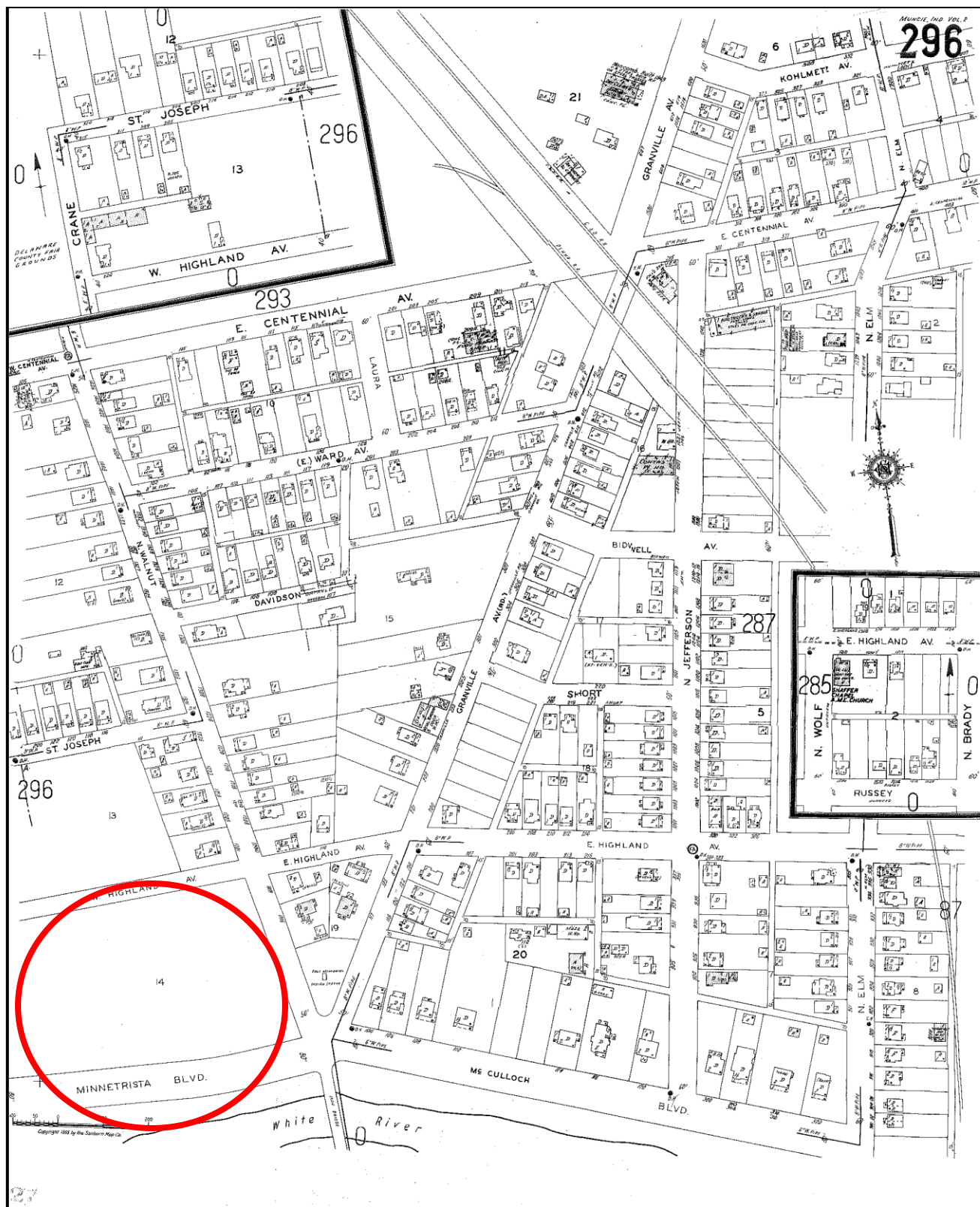


Figure 33: 1955 Sanborn Map of Minnetrista East Lawn (Minnetrista Historic Complex 2016).





Figure 34: 1992 Google Earth Historic Aerial with Vegetation Patterns (Google Earth Historic Maps 2017).



Figure 35: 2016 Google Earth Aerial (Google Earth Maps 2017).



Figure 36: Southeast Corner of Orphans' Home Grid, Facing Northwest (Photo by Amanda Balough, 2017).

## Results

After data had been gathered, it was transferred to and processed in RADAN 7. Four filters were applied to the Orphans' Home data: block edit, time zero, FIR, and range gain. Block edit cuts off the bottom of the data. The original depth estimate was 4.44 meters and the block edit function was used to shorten the data to 3.48 meters. The time zero correction was -4.03. Background removal was done simultaneously with the FIR filter, with a high pass of 300 and a low pass of 540. The final filter applied was range gain. Range gain amplifies reflections with increasing depth, which allows for better interpretation of subtle signals (GSSI 2015). Seven points for gain were applied at 15, 25, 35, 45, 55, 65, and 75.

Once RADAN processing was completed, two types of anomalies were identified. Each anomaly was assigned a number and a description is provided in Table 10. Images of time slices were made at 10 centimeter intervals with 5 centimeter thicknesses and radargrams (profiles) were also created (See Appendix B: Figure 77 to Figure 83).

Anomaly 1 is a series of surfaces and hyperbolas located in the northwest corner of the grid. Field observations noted that there was a depression in that area. Anomaly depths range from 17 centimeters to 23 centimeters below ground surface. The best time slice for Anomaly 1 is presented in Figure 81, in which Anomaly 1 forms a slight curve. Anomaly 1 is also in close proximity to the square vegetation pattern seen in the 1992 aerial photograph (**Error! Reference source not found.**). Based upon the position of Anomaly 1 and its association with the features in the aerial photos and the Sanborn maps, Anomaly 1 is the possible foundation of the laundry outbuilding, just north of the Orphans' Home. A surface extending off of Anomaly 1, seen in Figure 81, could potentially be a slab which stood in front of the building or a path, potentially leading toward the Orphans' Home.



Anomaly 2 is various, highly reflective points, seen in Figure 77 and Figure 78, at the ground surface and 10 centimeters down. Due to the highly reflective nature of the features, they may be metallic objects or air voids. Notes from the 2000 and 2002 Public Archaeology week, directed by Mitchell Zoll, indicated a number of fragmented brick and fire-cracked rock pieces. However, individual brick fragments and FCR are too small to be detected by this radar survey.

Table 10: Orphans' Home Anomalies.		
Anomaly #	Depth	Description
Anomaly 1	17-23 cm	Anomaly 1 is a series of surfaces and hyperbolas. Possible foundation of laundry outbuilding.
Anomaly 2	Various	Anomaly 2 is various highly reflective points that are probably metallic objects or air voids.

The goal of the Orphans' Home survey was to identify the location of the home's foundation. However, the survey potentially located one of the northern outbuildings that was associated with the Orphans' Home, seen in **Error! Reference source not found.** If Anomaly 1 is one of the outbuildings, then the radar results suggest that the home's foundation is located in the area of the 1999 shovel probe tests. However, the modern landscape of the East Lawn appears to have experienced several episodes of landscape development and those episodes of development may have potentially removed much of the Orphans' Home remains, especially if the materials for the Home were removed and recycled. Another explanation for why the foundation remains could not be located is that the survey grid itself was too small and the survey missed the remains.



## **Eaton House (1964-Present)**

### **Site Background**

The Eaton House is unique in comparison to the other sites in that the Eaton House is a modern structure and the purpose of the survey was to locate modern features. The site is located approximately forty-five minutes northeast of Ball State University in the town of Eaton, Indiana. The house came under current ownership in 2007 (Figure 37). There has been very little landscape disturbance in the backyard, other than the installation of a septic tank and leach field lines in 2006 and a garden that was installed in 2012 in the eastern boundary of the 0.5 acre lot (Personal communication with Donita Drake, 2016).

### **Structural Design**

The Eaton House is a modern Ranch style house built in 1964 (Trulia 2017). The Eaton House is a one-story, three bedroom house, with a hipped roof and a front entrance located on the western side of the building. The structure is simplistic in design with overhanging eaves and a recessed front entry (McAlester 2015: 597-598).

### **Previous Archaeological Investigations**

No previous archaeological investigations have taken place in the survey area. The landowner did inform the field crew that they had created a garden in the south-eastern corner of the survey grid, which may potentially be seen in the radar data.



Figure 37: Street View of Eaton House, Facing East (Google 2016)

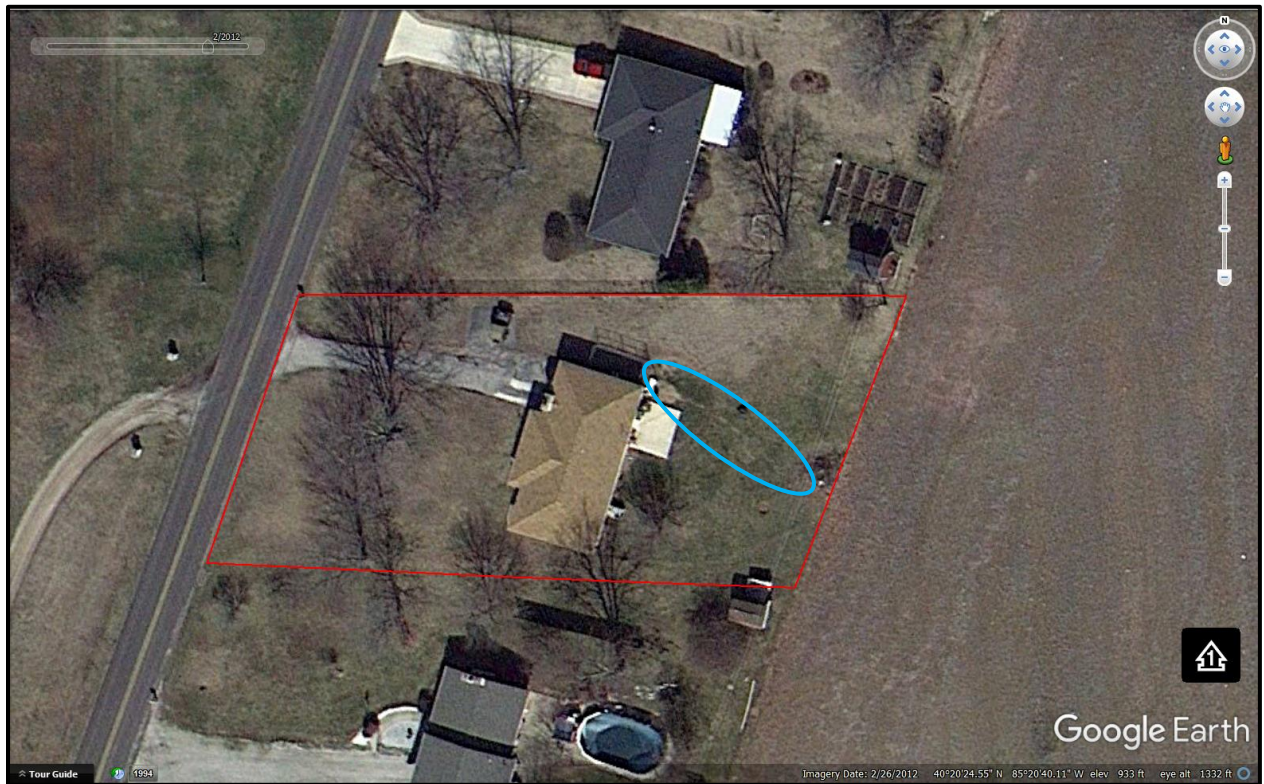


Figure 38: 2012 Historic Aerial with Possible Septic Line Circled in Blue (Google Earth 2017).

## Soils

Two soil types are located on the 0.5 acre property, with 53% of soils being Urban land-Glynwood (UetB) soil and 47% of soils being Glynwood silt loam (GlrB2) soil (Table 11). The western half of the property, where the house and driveway are located, is the Urban land-Glynwood soil, while the eastern half of the property, which has experienced less construction disturbance, is the Glynwood silt loam (USDA 2016).

Table 11: Soil Information for Eaton House (USDA 2016).						
Type	Abbreviation	Landform	Material	Slope	Percentage of Parcel	Comments
Urban Land-Glynwood	UetB	Till plain	Loess over clayey till	2-6%	53%	Moderately well-drained
Glynwood silt loam	GlrB2	End and ground moraines	Wisconsin limestone and shale till; silty clay loam	1-4%	47%	Moderately well-drained

Urban land-Glynwood soil consists of land covered by urbanization, such as streets, buildings, and parking lots. Urban land-Glynwood (UetB) is located on till plain, with one to four percent slope (USDA 2004). The soil is moderately well drained and consists of loess over clayey till.

Glynwood silt loam is the undeveloped version of Urban land-Glynwood soil and is located in the eastern half of the property, which was the targeted area for survey. Located on end and ground moraines on till plains, Glynwood soil has a one to four percent slope and is considered prime farmland (USDA 2016). A moderately well-drained soil, Glynwood soils consist of rich, silty clay loam. While this material may be good for agriculture, it can be challenging for GPR survey, as the clay can attenuate the radar signal.

Field notes taken during the survey recorded that there had been rain the day before the survey and that it was actively drizzling during survey. Wet surfaces can cause serious issues for radar survey because more of the radar energy bounces off of the surface when the conditions are wet. The GSSI dielectric constant chart indicates that clayey soil has a dielectric constant of 2.5, but with the presence of water, the dielectric constant will be around 27.

### **GPR Survey Methods**

The Eaton House was of interest for survey because it would allow the author to gain experience with what modern features look like in GPR data. The landowner needed to have work done on the septic tank and was unsure of the location of the tank in the backyard. They volunteered their property and permission was granted for ground penetrating radar (GPR) survey to be conducted on site. Once permission was granted, the survey team corresponded with the landowner to determine the date for survey. Sanborn maps and plat maps were consulted to determine more efficient placement of the survey grid. A 2012 Google Earth aerial photograph (Figure 38) shows what might be a possible vegetation pattern related to the installation of the septic line, running from the northeastern corner of the building out towards the west parcel boundary (Google Earth 2017). No Sanborn maps indicated the location of a septic tank or line.

The survey was conducted on December 8, 2016. Field observations noted that there had been rain the day before survey and the area for survey had been recently mowed, with no obstacles to impede survey. The GPR unit was set up and run across the ground several times to see if there were any areas of interest. Based upon the orientation of features observed in the test radargrams and advice from the landowner, who thought the septic tank might be located in the northeastern quarter of the property, a grid was set up along the eastern property boundary. The grid measured 13 meters by 15 meters and was established with a northern orientation; transects

were gathered south-north along the Y-axis. A dielectric constant of 20, to account for ground saturation, was set and the unit gathered 50 scans per meter and 512 samples/scan to an estimated depth of 4.44 meters. Data were collected at a medium density, with transects spaced 0.5 meters apart, for a total of 27 radargrams. The field crew consisted of the author and Dr. Mark Groover.

## **Results**

After the data had been gathered, it was transferred to and processed in RADAN 7. Three filters were applied to the Eaton House data: block edit, time zero, and FIR. The original depth estimate was 4.44 meters and block edit was used to shorten the data to 2.61 meters. The time zero correct was -1.34. Background removal was done simultaneously with the FIR filter, with a high pass of 200 and a low pass of 635.

Once RADAN processing had been completed, two anomalies were identified. Each anomaly was assigned a number and a description is provided in Table 12. Images of time slices were created at 10 centimeter intervals with 25 centimeter thickness, and radargrams (profiles) from each anomaly are also provided (see Appendix E:Figure 87 to Figure 94).

The surface to 20 cm below ground surface contains many strong reflectors that are more concentrated in the southwestern corner of the grid, closer to the house. These reflectors may be construction debris, as they do not form any pattern related to construction or intentional dumping (Figure 87 to Figure 89).

Anomaly 1 is a hyperbola feature, likely a pipe that cuts across the southern half of the grid. Its highest point is at 25 cm below surface on the southern boundary and as it travels northwest it gradually slopes down to its deepest point at 50 cm below surface (Figure 91 and Figure 92). During survey, the landowner noted that Anomaly 1 appears to lead out from the

bathroom and when compared to the 2012 Google Earth aerial photograph, Anomaly 1 matches the location of the observed vegetation pattern (Figure 38).

Anomaly 2 is a series of point hyperbolas that are 1.5 meters wide and 2 meters long and is located 2.5 meters from the eastern grid boundary (Figure 87 to Figure 90). The hyperbolas generated a strong signal, with longer tales and repeated echoing, an indicator that the points may be caused by a metallic object. According to the landowner, a garden bed was located in the eastern boundary of the grid and Anomaly 2 may be stone or bricks associated with the garden bed.

Table 12: Eaton House Anomalies.		
Anomaly #	Depth	Description
Anomaly 1	25- 50 cm	Anomaly 1 is a point hyperbola that gradually sloped from the western boundary toward the south-eastern corner of the grid. Appears to line up with vegetation pattern in 2012 aerial. Septic line.
Anomaly 2	5 cm	Anomaly 2 is a series of point anomalies that is 2 meters long and 1.5 meters wide. Possible garden bed.

The Eaton House provided the opportunity to see what modern features would look like upon a very intact landscape. While the GPR survey at the Eaton House may have been unable to detect the septic tank, the survey did find a utility line, most likely a septic line. Based upon the GPR results, the Eaton House has had very little landscape change, as Anomaly 1 is an indication of modernization and recent development in the landscape history. Anomaly 2, potentially a garden bed, is an example of how humans exploit the landscape, either for food production or recreation purposes.

## Analysis Discussion

The GPR technique produced useful results at all of the surveyed sites. As presented in the case studies, geophysical methods have a varying degree of success when detecting subsurface features. Multiple conditions can affect the detection of anomalies, such as construction technique, water saturation, and modern disturbances. Here I will discuss the success of the GPR in detecting anomalies associated with each site's research interest. I have classified the five sites surveyed into three groups: Class 1, Class 2, and Class 3.

Table 13: Survey Area's GPR Result Summary.							
Survey Area	Class	Acreage	Soil Type	Saturated Soil	Defined Anomalies	Less Defined Anomalies	Single Hyperbolas
Moore-Youse House	1	0.05	Silt and Clay Loam	No	3	1	7
McGowan Hall	1	0.19	Clay Loam	No	3	3	25+
Eaton House	1	0.05	Clay Till	Yes	1	1	20+
Nottingham Cemetery	2	0.04	Silt Loam and Clay	Yes	4	6	25+
Orphans' Home	3	0.024	Silt Loam and Clay	Yes	0	3	30+

In this discussion, “Class” is related to the number of defined anomalies versus the number of less defined anomalies. Class 1 sites have more “defined anomalies” than “less defined anomalies” and include anomalies that have either crisp, identifiable features or are in association with a known landscape feature (e.g., a rectangular sub-surface anomaly in proximity to known location of archaeological test unit from field school map). Class 2 sites have an equal number of defined versus less defined anomalies. Class 3 is when the number of defined anomalies is less than fifty percent of the less defined anomalies. The “success” of the GPR survey is gauged by how clear subsurface anomalies are and how easily interpretable they are. I will first begin by discussing the Class 3 survey and conclude by discussing the Class 1 surveys.

### Class 3: Orphans' Home Discussion

The Orphans' Home survey is the only Class 3 site out of the five selected sites. Field notes from the day of the survey indicate that the ground was saturated from recent rain and with the soil being a combination of silt loam and clay, there is the risk for attenuation of the signal in the data analysis. Landscape theory was applied when reviewing Sanborn maps and old photographs of the landscape. Based upon the historic maps and photographs, the Orphans' Home was situated on the rise of the East Lawn, just east of the modern Minnetrista Cultural Center. Unfortunately, the 1896 Sanborn map (Figure 32**Error! Reference source not found.**), which was the only historic map that provided any distinct outline of the Orphans' Home and outbuildings, could not be georeferenced onto a modern map of the landscape. The section of the Sanborn that displayed the Orphans' Home was a small inset map and it could not be georeferenced properly. An approximate location was determined based upon the positioning of old photographs and 1992 and 2016 aerials photographs with a distinct rectangular vegetation pattern, which could be the remains of either the Orphans' Home or one of the northern outbuildings (**Error! Reference source not found.** and Figure 35). The survey grid was positioned over the northwest corner of the vegetation pattern (Figure 97).

The GPR results were very faint due to the presence of the water. Overall, there were several reflective, individual surface and hyperbola anomalies within 20 centimeters of the ground surface (Figure 84 - Figure 86). They are thought to be metallic objects or voids given their reflective nature. There were three less defined anomalies that were present in the data. The one of most interest was Anomaly 1, which was a surface at 25 centimeters deep and was five meters long (Figure 84 and Figure 85). Located in the northwest corner of the survey grid, Anomaly 1 was very faint and positioned incorrectly to be the northern edge of the Orphans'



Home. Based upon the position of Anomaly 1 and the 1896 Sanborn map, Anomaly 1 could potentially be the laundry building, which was the closest outbuilding to the Orphans' Home.

Anomaly 2 is a faint surface extending south from Anomaly 1 (Figure 80, Figure 81, and Figure 85). Anomaly 2 is located between 20 and 25 centimeters below ground surface, is about a meter long, and extends west from the southern edge of Anomaly 1 towards the western boundary of the survey grid (Figure 81). My interpretation is that Anomaly 2 was a path leading from the southern entrance of the outbuilding, seen in Figure 30, towards the Orphans' Home.

Anomaly 3 is the faintest and most ephemeral of the anomalies. A surface seen at 20 to 25 centimeters, there is really no explanation for what Anomaly 3 is (Figure 86). Sanborn maps had shown no other structures east of the two depicted outbuildings, but it is possible that Anomaly 3 could be the compact dirt floor of a shed or smaller outbuilding.

Since all three anomalies are at consistent depths and the surface directly above each anomaly is not disturbed, modernization theory suggests that these anomalies were created at the same time period. However, the most confusing aspect of this survey is the appalling lack of debris. The site of the orphanage was relocated to the south side of Muncie in 1906 and Frank C. Ball purchased the land (Pearson 2012; Vincent 2014). It is unknown if the Orphans' Home was demolished or if it was taken apart and the pieces salvaged. Either way, there should have been a residual debris field from the dismantling of the Orphans' Home, which was a brick structure. Another possible explanation is that the size of the survey grid was too small and the survey missed any foundation remains. Two excavation units from the 2001 Public Archaeology Project supervised by Mitchell Zoll did recover a few pieces of brick and limestone; however, based upon the low number, the brick and limestone were not considered to be related to the Orphans' Home (Figure 31). Another aspect that needs to be considered is how modern landscape

development would affect any structural remains. The modern landscape shows evidence of soil being displaced and relocated. If there was a debris field left from the demolition of the Orphans' Home, modern landscape development could have removed any trace of it. However, if Anomalies 1 and 2 are related to the outbuilding, there may be remains of the Orphans' Home foundation just south of the survey grid location.

### **Class 2: Nottingham Cemetery Discussion**

Nottingham Cemetery was designated as a Class 2 site due to the fact that out of the six larger anomalies, four of them ( $n=66\%$ ) were identifiable with a degree of certainty. Field notes from the day of the survey indicate that the ground was saturated from recent rain and with the soil being a combination of silt loam and clay, there was a risk for signal attenuation. Landscape theory could not be applied for much pre-survey analysis due to a lack of Sanborn maps or historic photos showing the original layout and design of the headstones. However, Robert Good, the director of the Delaware County Historical Society, assured the survey crew that the headstones were in the original locations that they were in when the Historical Society took ownership of the cemetery. Good was also present during the survey and suggested the location of the survey grid to target an area thought to have unmarked graves (Figure 98). Modernization theory cannot be applied either, as the only modernization the cemetery has experienced has been surface development from preservation methods. Based upon the presence of five headstones within the survey grid itself, it was estimated that at least five graves would be seen in the GPR data.

As noted previously, the soils were a combination of silt loam and clay. By itself, this would cause some difficulties because the clay might prevent the signal from penetrating deep enough to detect graves. The presence of the recent water in combination with the clay highly

influenced the GPR data. Looking at the radargrams from the data, anomalies that are not metallic or stone in composition are very faint, which is why four of the anomalies not in proximity but displaying grave characteristics are labeled as possible graves.

### **Class 1: Eaton House Discussion**

The Eaton House survey is the first of the three Class 1 sites surveyed for this thesis. Field notes from that survey indicate that there had been rain the day before the survey and that it was lightly raining during survey. The soil in the survey area was clay till, which when wet can limit the depth of the radar signal penetration. As the purpose of the Eaton House survey was to locate the modern septic tank, an analysis of historic aerial photographs and Sanborn maps was conducted to search for an indication of the placement of the tank. The homeowner of the Eaton House suggested that the position of the tank could potentially be in the northeastern corner of the survey area (Figure 38). A search of the Sanborn maps showed no indication of the septic tank, but a 2012 Google Earth aerial (Figure 38**Error! Reference source not found.**) revealed a faint line in the vegetation. Normally this kind of vegetation pattern indicates the presence of subsurface material that either prevents or encourages growth. The same instance can be seen in the Orphans' Home survey. Based upon the direction of the vegetation growth, it appears that this linear feature coming from the northeast corner of the house, which was confirmed by the homeowner to be a bathroom, is heading towards a darkened half circle on the eastern boundary of the property. Field notes recorded that the half circle seen in the aerial was a surface depression with a tree growing in the center. The homeowner suggested that the possible locations for the septic tank would be either in the northeastern corner of the property or in proximity to the surface depression (Figure 99).

From the ground surface to twenty centimeters below, multiple highly reflective anomalies are seen throughout the survey grid and are interpreted as being modern debris and thus the most recent development (Figure 88, Figure 89, and Figure 95). Anomaly 2, which was a series of point anomalies two meters long and one and a half meters wide is also seen in Figure 88, Figure 89, and also Figure 90. Anomaly 2 is deeper than the debris and is highly reflective, indicating the presence of distinct material, perhaps gravel, brick, or even metal. The landowner, after being informed of the location of Anomaly 2, suggested that this was the location of a garden bed. However, the landowner could not provide any possible explanation for the presence of the metallic objects.

Anomaly 1 was in the exact location of the noted vegetation patterns seen in Figure 38 and is a line of highly reflective hyperbolas that is at a consistent depth as seen in Figure 95. The characteristics of the hyperbolas are similar to those seen in the case study of the Inter-Urban Rail Line Site, which was also looking for a linear modern feature. Based upon those characteristics, Anomaly 1 is the sceptic line and leads toward the half-circle depression mentioned earlier, which is the potential location of the septic tank itself. Based upon the lack of deeper features, Anomalies 1 and 2 are the most modern landscape development for the Eaton House survey.

### **Class 1: McGowan Hall Discussion**

The McGowan Mansion survey was the second of the three Class 1 sites surveyed for this thesis. Field notes from the survey indicate that there had been no rain two days prior to survey. However, rain would likely not be an issue in this case since the survey interest was located underneath the parking lot of the Indianapolis Knights of Columbus headquarters. Landscape theory was applied in the analysis of historical documents, such as plat maps, Sanborn maps, and

historic photos. **Error! Reference source not found.** is a Sanborn map that showed the landscape at 1963, prior to the deconstruction of the mansion and the carriage house and the paving of the modern parking lot. As the parking lot is currently present, there are no visible surface features available to give any indication of mansion remains (Figure 100).

Out of the five surveys, the GPR results for the McGowan Mansion were the clearest and best defined. Chronologically, Anomaly 1 is the deepest anomaly, as it is the remains of the Mansion foundation and cellar (Figure 69, Figure 70, and Figure 74). It consists of a series of hyperbolas and surfaces reflecting off of the foundations and other debris filling in the foundation. It is possible to see the internal wall framework in Figure 68, which is very visible and contrasts sharply against the surrounding soil composition. Anomaly 1 is the oldest anomaly, as there are no other anomalies below Anomaly 1. The next chronological anomaly is Anomaly 3 (Figure 66, Figure 67, and Figure 76). Anomaly 3 is a reflective, circular feature that is located beneath the surface feature of Anomaly 2. Ten meters in diameter, Anomaly 3 is 25 cm below ground surface and highly reflective. It is thought that after the driveway was shifted from the south side of the mansion to the north side in 1896, the driveway paved over Anomaly 3 (Figure 68, Figure 69, and Figure 75). Anomaly 2 is a surface that is on top of Anomaly 3, meaning that Anomaly 2 was created after Anomaly 3 and is the most modern large feature other than the modern parking lot. Based upon the positioning and reflective quality of Anomaly 2, it is probably the 1896 driveway which would have lead back to the carriage house, seen in Figure 26.

### **Class 1: Moore-Youse House Museum Discussion**

The Moore-Youse House survey is the last of the three Class 1 sites and considered the most successful GPR survey due to the clarity of the detected anomalies. Because it was also

occupied for the longest time period (n= 123 years), the Moore-Youse house also has the potential to display the most developed landscape due to modernization. Field notes from the day of survey noted that it had not rained within two days of survey and the ground was not saturated. Therefore, the soil conditions were ideal for radar survey. An evaluation of historical documents and maps was conducted prior to survey to provide context on the landscape development of the plot. The 1882 and 1892 Sanborn maps of the block showed the presence of the house, as well as two outbuildings (Figure 21). While the maps do not show the presence of any interesting structures or features, the 2004 Ball State University archaeological field school led by Dr. Mark Groover did encounter buried deposits. The field school conducted a series of shovel test pits and excavation units on the property to identify areas of high and low cultural material. Figure 22 and Figure 23 present the areas targeted and excavated during the 2004 field school. As the Moore-Youse House survey was suggested in lieu of future archaeological excavation, grid placement was oriented to target areas of future excavation. This area was the middle of the yard (Figure 101).

The GPR results displayed four large anomalies of interest, along with a few smaller individual hyperbolas. Anomaly 1, related to the sidewalk, was the most recent and modern of the anomalies and was located on the ground surface (Figure 55, Figure 56, and Figure 64).

Chronologically, Anomalies 3 and 4 are the next most recent anomalies (Figure 59, Figure 60, and Figure 63). Both appear to be filled in depressions that go down to a depth of fifty centimeters and are rectangular in nature. Both anomalies interrupt the topsoil stratigraphy, suggesting their chronological order. Based upon the location of the anomalies in comparison to the 2004 excavation units, both Anomalies 3 and 4 are probably excavation units (see Figure 101).

Based upon soil stratigraphy, Anomaly 2 is the oldest of the four anomalies (Figure 56, Figure 57, and Figure 63). Anomaly 2 is a series of reflective hyperbolas that is eight meters long and bisects the grid horizontally. The feature begins seven and a half meters north of the southern grid boundary and is highly reflective and crisp, indicating it may be metallic in nature, similar to the septic line seen in the Eaton House survey. Anomaly 2 runs from the Moore-Youse House towards the north-east corner of the Delaware County Historical Society headquarters. Anomaly 2 is the oldest of the anomalies, as the soil stratigraphy above the anomaly is undisturbed, an indication that the soil was formed after the placement of the line.

## **Chapter 5: Conclusion**

The primary objective of this thesis project was to create a reference guide of anomalies and their characteristics from five historic sites of varying types over a linear time frame, starting from when the first Euroamerican settlers arrive in Indiana in 1810 and finishing with the twenty-first century. During this project and after the conclusion of each survey results, three overall findings became prominent. Those findings are:

- i. The strength and weaknesses of GPR in archaeological settings,
- ii. How historic site development is revealed by GPR, and
- iii. GPR as a way to ground truth the validity of primary sources when applied for site recreation.

### **The Strength and Weaknesses of GPR in Archaeological Settings**

Ground penetrating radar is a method that differentiates between the materials of subsurface features by measuring the amount of returning radar energy and recording the variation. The layers of subsurface materials have different properties that affect the velocity of electromagnetic energy propagation and the strength of the reflected waves (Dam et al. 2002). Water and soil type will affect the penetrative capabilities of the radar signal and can either enhance the signal or attenuate it.

When locating archaeological features, GPR is most effective in locating anomalies that are either substantial in size or are of contrasting material from the surrounding soils, such as how rock differentiates from sand. As displayed by the state reported survey and the case studies, GPR survey is most effective at sites where there are intact foundations remains and dense materials present in contrast to the surrounding soils, such as the McGowan Hall, the Moore-Youse House, and the Eaton House. At all three of these sites, there was little to no saturation



present to affect the signal. The denser material of the archaeological remains greatly contrasted with the surrounding soil and was vividly displayed in the data during analysis.

In contrast, fainter and fewer intact archaeological features were not displayed as vividly in the GPR data and the GPR is less effective at detecting them. The presence of saturated soils also attenuates the radar signal more. During the Orphans' Home survey, the soils were saturated and the defining anomaly appears to be a hard-packed dirt floor, which did not contrast as strongly from the surrounding soils as it would have if the soils had been drier. Sometimes the presence of water can enhance the differences between materials, but too much water will make the anomalies and surrounding soils appear homogenous.

Another strength of GPR when surveying archaeological sites is that it is easy to transport the survey equipment to a site. The equipment does not require a large crew to operate and conduct the survey effectively. Two of the surveys conducted for this thesis consisted of just a two-person crew and took about four or five hours to complete. Traditional methods of archaeology, which would include shovel test pits and open units, would take at least three times as long to conduct and would require more than two people crews. In that sense, ground penetrating radar is cost effective as it saves time and resources. The researcher benefits from a dataset that displays subsurface features without disturbing the ground surface, thus preserving the site for future research.

A weakness of GPR is that the equipment and the processing software can be expensive. If parts of GPR equipment get damaged and need to be replaced, it may take time to replace the piece and will be expensive. The processing software itself also requires knowledge of how to best apply and manipulate the raw GPR data to best display the survey results. As illustrated by this thesis, the raw GPR data process is time consuming and challenging to a novice of GPR.

## **How Historic Site Development is revealed by GPR**

Each of the five sites surveyed for this thesis was affected by landscape change that is attributed to human engagement with the natural environment. The GPR was applied to the sites to gain a better understanding of how the landscape changed and how modernization was applied to each site. For some sites, the effects of modernization were viewed more readily in the data, either because the site had a longer period of occupation, or use, and more landscape episodes or the features indicating landscape and modern development were more distinguishable in the GPR results. Modernization is reflective of cultural evolution and how that affects the usage of the natural environment, with developments of technology being an indication of site modernization. As noted by William Cronon (1983:162) “Economic and ecological imperialism reinforced each other.” Each did not develop independently from the other. Within multiple series of landscape changes over time comes a linear development of technology and modernization of the site. Ground penetrating radar reveals the indicators of the landscape modernization without disturbing the site.

To better analyze the process of modernization at the five sites, time was divided into a three-period time frame for site occupation. The early period, referred to as the Settler Period, dates from 1810 to 1885, from when Euroamerican settlers first arrived in Delaware County to when the gas boom began (Lasley 2012:7). The middle period, referred to as the Industrialization Period, dates from 1886 to the 1950s and consisted of the gas boom up until right after WWII. The final period, the late period, is the Modernization Period of Delaware County from the 1950s to the present (Lasley 2012:7). After the time periods were set, each site was analyzed by first the number of anomalies that could be identified to a known physical feature (i.e., sidewalk, headstones, etc.) and the number of anomalies that could not be associated to known features

(i.e., a small hyperbola close to the surface). Then each anomaly was attributed to a time period that the anomaly was created in. The results are presented in Table 14.

For each site, structural and landscape development is influenced by how long the site was occupied. For example, Eaton House has only been occupied since 1964 and is the youngest site, thus anomalies are only visible in the Late Period. Of the five sites surveyed, three sites displayed anomalies in one time period, one site reflected landscape change in two periods, and one site reflected modernization in all three time periods. Since GPR can spatially display subsurface features without disturbing them, the sequence of feature development remains intact and it is this sequence that reveals site modernization. For example, the McGowan Hall data had features from all three time periods. The earliest and deepest feature is the foundation, which dates to 1874 and places that first landscape development in the early period. The next features above the foundation, but not interrupting, are the remains of the driveway and the circular anomaly. Historical notes indicated that the driveway was laid not long after 1895, which places that landscape development within the middle period. The most recent landscape development at the McGowan Hall site was the paving of the modern parking lot, which is visible in the GPR data as a reflective surface right at the ground surface. In this manner, modernization is presented in the sequence of which anomalies are displayed, with younger and more recent anomalies overlaying older, deeper features. For most archaeological surveys, modern features and artifacts are disregarded because they are classified as modern. These later periods need to be included in the site discussion as it is part of the full landscape history of that site. Site history can be recreated by looking at the modernization of sites through the sequence of deposits of features visible to the GPR.

Table 14: Modernization of Sites Reflected through Anomalies.

Survey Area	Identifiable Anomalies	Early: Settler Period (1810-1885)	Middle: Industrialization Period (1886-1950s)	Late: Modernization (1950s-present)	Unidentified Anomalies	Early: Settler Period (1810-1885)	Middle: Industrialization Period (1886-1950s)	Late: Modernization (1950s-present)
Nottingham Cemetery (1845-1909)	4	Anomalies 1, 2, 3, and 4			31+	X	X	
Moore-Youse House (1859-1982)	3			Anomalies 1, 2, and 3	8			X
McGowan Hall (1874-1963)	3	Anomaly 1	Anomalies 2 and 3		28+		X	X
Orphans' Home (1890-1905)	0				33+		X	
Eaton House (1964-present)	1			Anomaly 1	21+			X

## **GPR as a Way to Ground Truth the Validity of Primary Sources When Applied for Site Re-Creation**

Primary sources are direct or firsthand evidence of an event, object, person, or piece of art. For archaeology, primary sources normally are historical documents such as legal writings, diaries, and personal manuscripts, as well as photographs and maps. These primary sources help guide the location of archaeological survey and the interpretation of archaeology results, as the primary documents normally are a reliable account of how human activity was reflected in the natural landscape. For example, if an archaeologist were to consult a map and photograph of a farm displaying a chicken coop within a yard and archaeology was conducted in the vicinity of the coop location, the recovered archaeological remains could be considered to be related to the coop. Primary sources are considered to be very accurate and reliable resources for an archaeologist and they play a significant role in data analysis and site reconstruction. However, primary resources are only reliable up to a certain extent.

Primary sources can provide context for a site during a specific time and within certain conditions. Any landscape change after the time of the primary source will affect the conditions of the site and begin to exhaust the validity of the primary resource. For example, several farming episodes over a known location of a Native American site will affect the archaeological remains. An old historic journal could describe the location, potentially the extent of the site, and inquisitive researchers would get the desire to investigate the remains. There may still be some preserved Native American features, such as hearths and trash pits, but not as many as there would have been if the farming episodes had not taken place. In this instance, because of the extensive farming episodes that would have altered the remains of the Native America features, the primary resource was not as reliable as it would be in other landscapes with fewer landscape

episodes. Archaeology can test the reliability of primary resources by researching the physical features and ground truthing for any remains. Ground truthing in geophysics is:

“...the effort to verify and enhance the results of a remote sensing study through the use of independent evidence. Note that the word *truthing* refers to the interpretations of the remote sensing data; it does not imply that the actual data may be spurious.”

(Hargrave 2006:269)

Hargrave notes that it is not the geophysical data that has the risk of being invalid and rather the primary source could be incorrect. Primary sources are created by humans and thus human error can be applied to the geophysical data interpretation as well as the primary sources.

As described in the methods section, prior to each survey a background check was conducted to research the landscape history of the site. All five sites had some form of a primary resource that could be consulted for site orientation. Nottingham Cemetery had genealogical records of who was buried in different rows along with a brief description of the cemetery's history, while McGowan Hall and the Moore-Youse House had historical maps and photographs of the structures. These resources provided guidance as to where to position the survey grid to gather data efficiently. While the GPR survey was intended to locate the archaeological features for the purpose of creating the reference guide, it also had the benefit of ground truthing any remains and testing the validity of the primary resources. The best example of when the primary resources reflected the GPR results was at the McGowan Hall site. At this particular site, the modernization of the landscape and development of the site is reflected in a series of historic maps and pictures of the hall. The earliest landscape episode was the construction of the hall, followed by the reorientation of the driveway from the south to the north side of the structure. The next event was the construction of the Knights of Columbus clubhouse, then the demolition

and covering of the McGowan Hall foundation and cellar, and finally the paving of the parking lot. The modern parking lot preserved the site by locking the landscape under a hard surface. The GPR results of the foundational remains were easily identifiable and were able to validate in great detail the historic maps displaying the Hall. In this instance, because there were few landscape events following the deconstruction of the Hall, the remains were hardly disturbed and the GPR survey successfully ground truthed and validated the primary resources for the McGowan Mansion.

The Orphans' Home survey was the least successful survey and had the most episodes of landscape development. The construction of the Orphans' Home and the two northern outbuildings were the first recorded event, followed by the installment of the apple orchard cared for by the orphans, and then followed by the demolition of the outbuildings and orphanage when the orphans' home was relocated to the south side of Muncie. After that, the site came under the ownership of the Ball family and then became part of the Minnetrista Cultural Center. There are fewer maps and images of the Orphans' home and of the two primary sources showing in detail the placement of the home on the landscape, there is a distance disparity between the two. The map of the site showed the orphanage to be placed back from the White River; however, a photograph of the orphanage showed it placed very close to the bank of the river. The photo also showed a very gentle slope grading towards the river, yet field observations from the day of the survey noted a very steep slope to the riverbank. Field observations also noted areas where the rise on which the orphanage may have been graded. These observations suggest heavy landscape development that is not reflected in the maps and photographs and that may have negatively impacted any foundation remains from the orphanage. The GPR grid was positioned over the rectangular vegetation pattern noted in the Google aerial, since the vegetation pattern was the

approximate size and location of the orphanage as reflected by the map. The GPR survey did not locate any features associated with the orphanage, such as a cellar or debris field from the deconstruction, but it may have located what could have been the dirt floor of the laundry building just north of the orphanage home. This would indicate that the orientation of the orphanage on the map is incorrect and that the positioning of the orphanage is closer to the river as shown in the photograph. However, there is the possibility that there are no intact foundational remains left at the site. As mentioned before, the difference of the slope of the riverbank from the historic photograph and the modern landscape indicated heavy landscape modifications to the site. Because of the heavy modification, there may not be any foundation remains of the orphanage left to ground truth, which calls into question the validity of the photographs and maps upon the modern landscape.

The process of ground truthing encourages the researcher to think critically about the emphasis that is placed on primary sources. Primary sources are generally undisputed and accepted to be reliable. However, with further development and refinement of geophysical instruments and practices, researchers now have the ability to ground truth archaeological features in a detailed way and can question the validity of primary resources, especially when a site has undergone several episodes of landscape development. The takeaway from this final finding is that primary sources should not be taken at face value and, now with the assistance of refined technologies, the researcher is able to test the validity of the sources.

## **Further Research and Work**

The purpose of this master's thesis project was for the author to gain knowledge and experience in the application of geophysics, specifically ground penetrating radar survey method,



to historic sites and to create a reference guide for novices. Not one survey was identical, as the site type, field conditions, and survey method differed per each survey area. To organize and guide research, landscape theory was applied for pre-survey investigation, in which maps and photos were consulted to provide landscape context for the site and to guide the most strategic placement of the survey grid. Once data had been gathered, modernization theory was applied to help with anomaly identification and to understand the landscape development of the site into the twenty first century.

Future research would involve the application of other geophysical methods to the five sites to see if a different survey method would complement or contradict the GPR findings. As presented in the case studies, geophysics often is best employed in archaeological settings when multiple survey methods are applied and compared. The Applied Anthropology Laboratories has access to a Geoscan Research RM15 resistance meter, which measures the resistance of soils. Since the Orphans' Home is a site of interest for a future archaeological field school, it is recommended that another geophysical survey method, such as soil resistance with the Geoscan RM15, be applied.

Surveys of larger areas should be conducted at the Nottingham Cemetery, the Moore-Youse House, and the Orphans' Home. As noted in the Orphans' Home discussion, the possible explanation for why the GPR results did not show any deconstruction debris was because the survey area was limited and missed any archaeological remains. If the site was revisited, a larger grid would be surveyed closer to the riverbank. For the Moore-Youse House, the whole yard could be surveyed. This would allow for the whole landscape to be analyzed, rather than a small portion. The Nottingham Cemetery had more areas with possible locations of other unidentified

graves that could be surveyed. By returning to all of the sites, more surveys would allow a more complete scope of the landscape history.

While this thesis project allowed the author to gain sustainable experience and training in geophysics, there is still much left to learn. Geophysical survey equipment continues to advance in its usefulness on archaeology sites, and instruments and software created by other manufacturers can produce distinctly different results. Finally, there is a vast literature on the application of geophysics to archaeology sites from around the world. Examination of survey results from outside Indiana would surely help to better understand the results from the sites presented here.

## **Glossary**

Anomaly - Something that deviates from what is standard, normal, or expected.

Attenuation – “A measure of the loss of radiate signal amplitude or signal energy as it progresses through a lossy medium. The loss can be due to a spreading loss as the wave expands out into the medium and also due to an ohmic loss, due to the finite conductivity of the medium” (GSSI 2012: 121).

Background Removal – “A digital signal processing function that filters by subtracting an average of a large number of scans from each individual scan. The result is horizontal changes in the data are accentuated while linear features (background) are suppressed (GSSI 2012:121).

Decoupling – When the carriage of the antenna temporarily breaks contact with the ground surface.

Deconvolution – “A digital signal processing function designed to attenuate multiples and improve the recognition and resolution of reflected events. A process that restores a wave shape to the form it had before it underwent a linear filtration action (convolution)” (GSSI 2012:122).

Electrical Resistivity- An active survey method that injects energy into the ground through a probe array and records the response of the electromagnetic energy (Somers 2006:109).

Electromagnetic Conductivity- A survey method that generates and transmits an electromagnetic field from a coil into the ground to measure the electrical conductivity of the soil.

Finite Impulse Response (FIR) Filter – “A digital signal processing function that convolves a finite length function (boxcar, triangle) with the data. Each data value is multiplied by

the corresponding filter value and added together. FIR filters are digital filters and have no time delay” (GSSI 2012:122).

Geophysics – Natural science study of the physical process and properties of the Earth, such as the Earth’s shape, gravitational and magnetic fields, and plate tectonics.

Geophysical methods – Technological equipment that measures and records seismic, gravitational, magnetic, electrical, and electromagnetic properties of the Earth.

Ground Penetrating Radar (GPR) - An active survey method that involves radar energy being transmitted into the ground and recording the properties of the returning signal.

GPRSlice – A computer program for analyzing GPR data.

Landscape theory - The study of the ways that past peoples have constructed, altered, and/or lived in the environment(s) around them (Rossignol and Wandsnider 1992: 4).

Magnetometry- A passive survey method that records variations in the earth’s magnetic field close to the earth’s surface.

Metal Detection - An active survey method that generates a conical shaped signal to detect metallic objects close to the ground surface.

Migration – “A digital signal processing function that rearranges data so that reflections and diffractions are plotted at the locations of the reflectors and diffracting points rather than with respect to observation points on the profile. Migration by computer is accomplished by integration along diffraction curves by numerical finite-difference downward-continuation of the wave equation and other algorithms” (GSSI 2012:123-124).

Modernization theory – An Abstract social theory that combines processes from sociology, history, psychology, anthropology, and economics. Modernization typically views

processes in a phased linear progression of events and is heavily influenced by linear evolution and functional theory.

Moraine - Piles of debris which are deposited from when a former ice front was static.

Non-invasive- No digging or disturbing of the ground surface or any sub-surface features.

RADAN – Radar Doppler Automatic Navigation A computer program for analyzing GPR data.

Range Gain – “Also known as time gain control or time varying gain. Control for varying the amplification or attenuation of an amplifier, use to compensate for variations in input signal strength over time” (GSSI 2012:124).

Relative Dielectric Permittivity (RDP) – Also referred to as the dielectric constant, RDP accounts for electrical and magnetic properties of subsurface features and is a measure the feature’s ability to store a charge and then transmit the energy (ASTM International 2003; Von Hippel 1954; Wensink 1993).

Settler Colonialism theory - The process of the erasure of the indigenous population by the settler nationalism, who also strives to differentiate themselves from the settler’s mother country (Wolfe 2006:389).

Siemens- A unit of conductance used to quantify a material’s ability to conduct electricity. It is the reciprocal of resistance, for example, in the study of soil.

Time Zero - Adjust the first positive peak of the wave to be at the ground surface to provide a more accurate depth calculation (GSSI 2012: 39).

Transect – A straight line across the earth’s surface, along which observations are made and/or measurements taken.

Trimble – A handheld Global Positioning System device that records point locations with fine-grain precision.

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## Appendix A: Nottingham Cemetery Time Slices and Radargrams

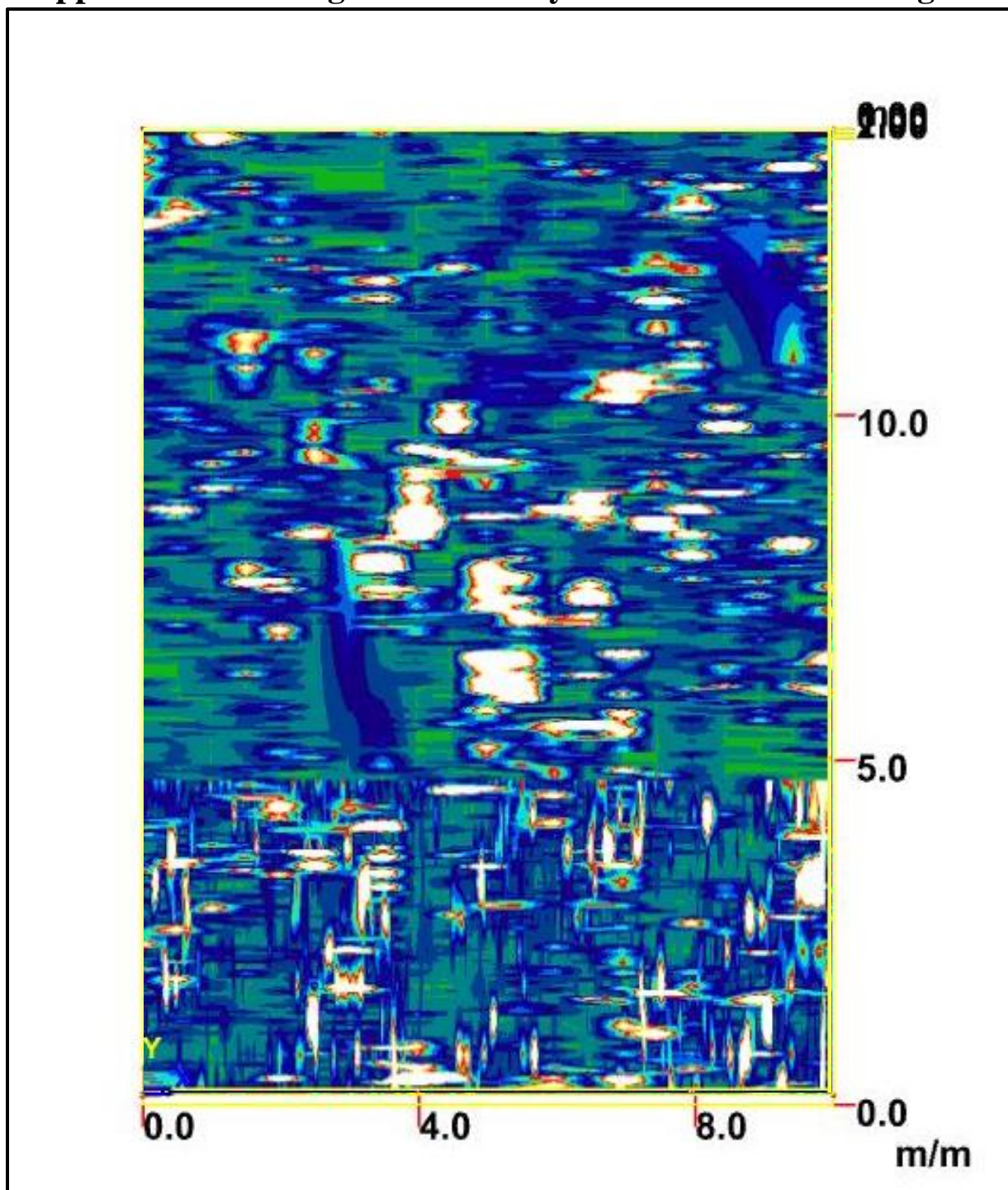


Figure 39: Nottingham Cemetery 0 Depth. \*In all images, radar reflection intensity is indicated as blue=weak, green=moderate, and white= strong.



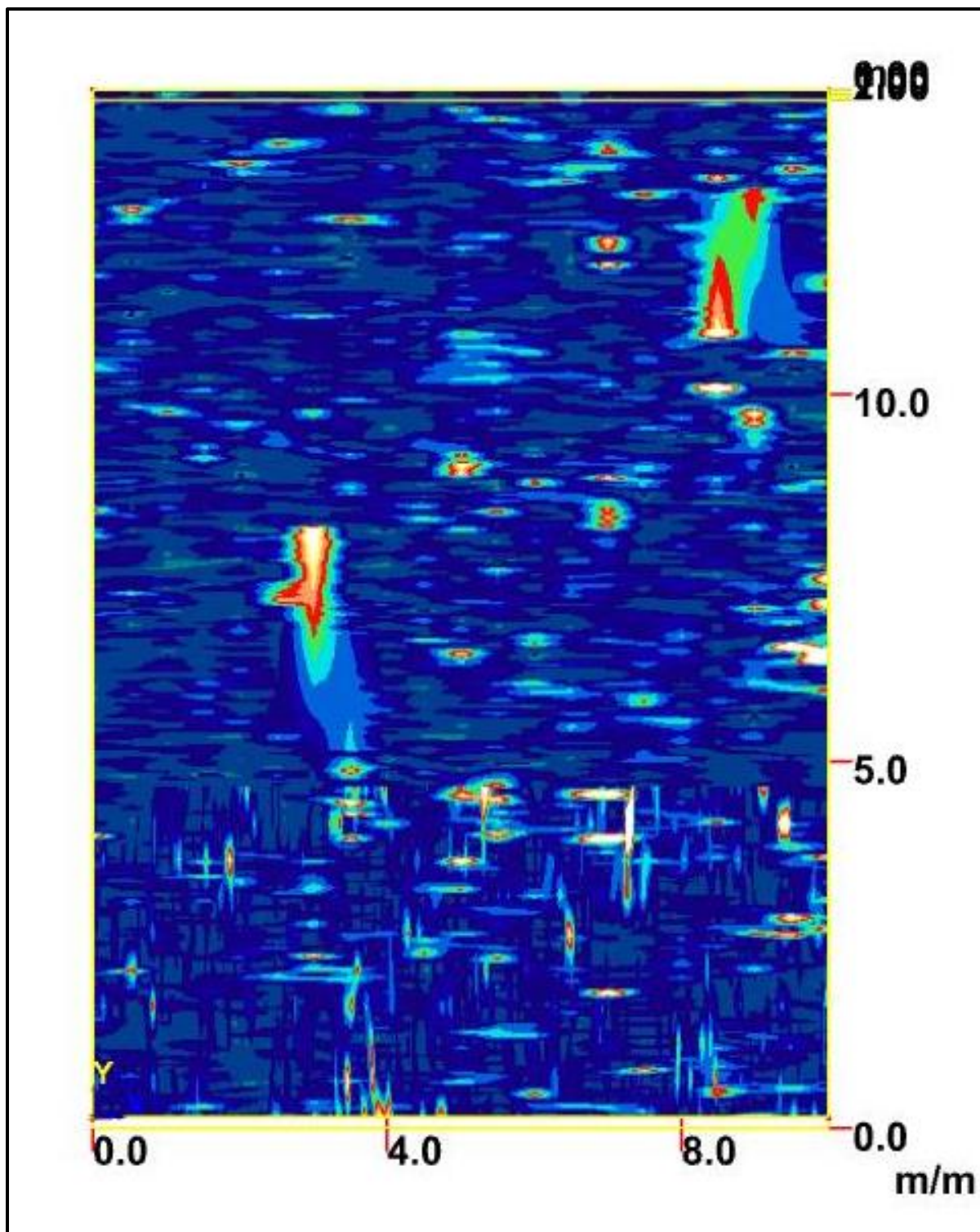


Figure 40: Nottingham Cemetery 10 CM below Ground Surface.

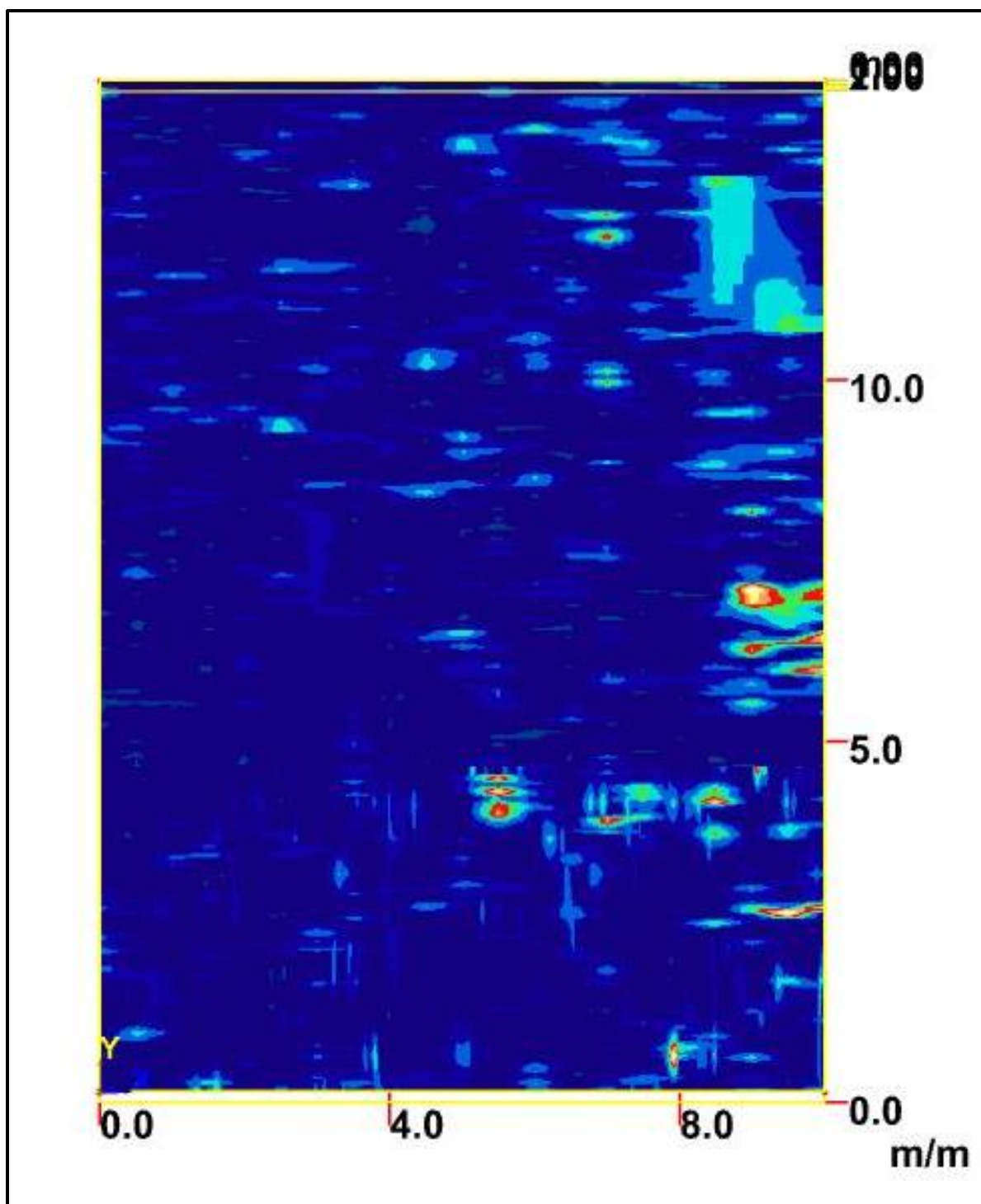


Figure 41: Nottingham Cemetery 20 CM below Ground Surface.



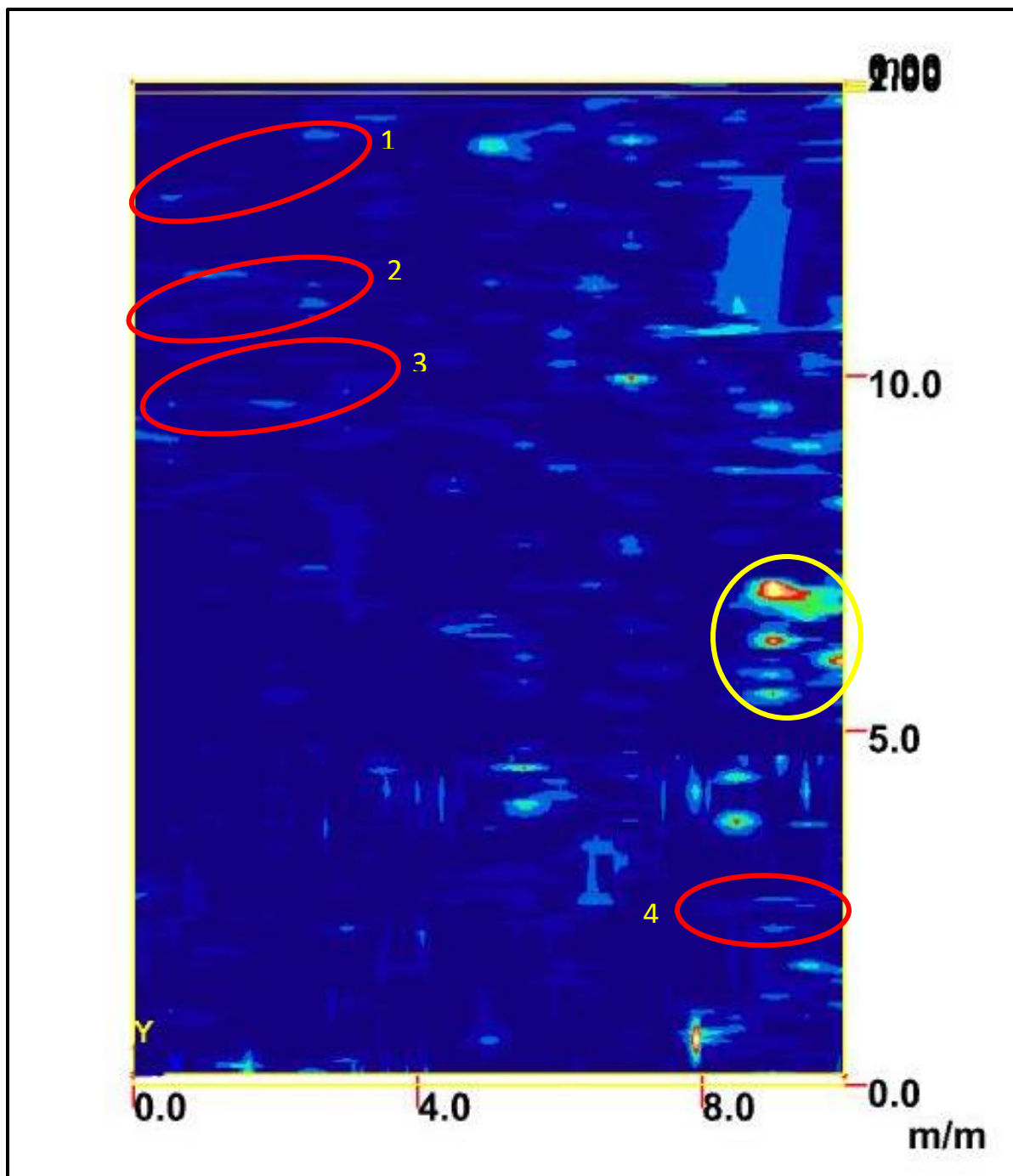


Figure 42: Nottingham Cemetery 25 CM with Likely Graves 1, 2, 3, and 4 and Anomaly 8 (Yellow).

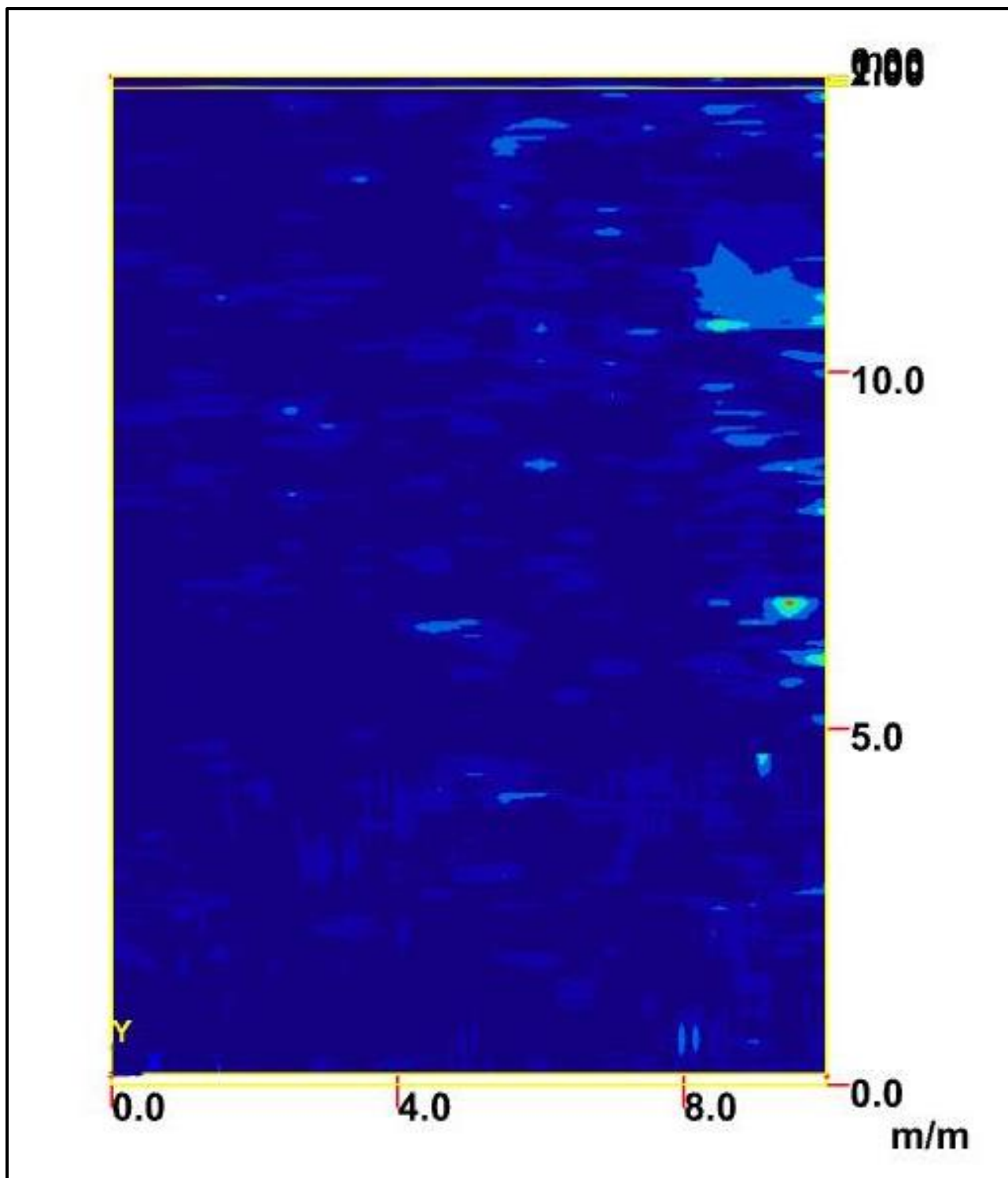


Figure 43: Nottingham Cemetery 30 CM.

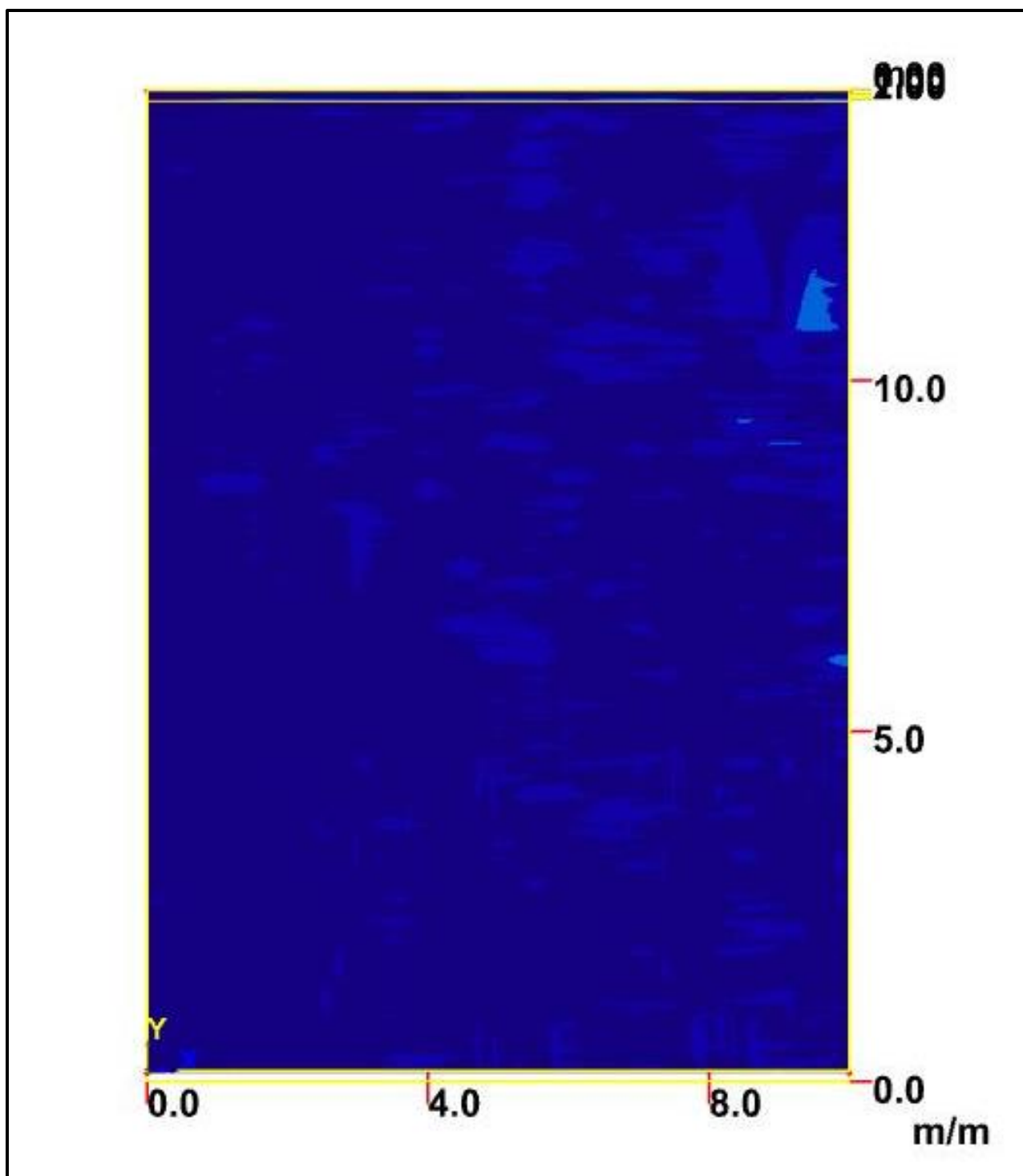


Figure 44: Nottingham Cemetery 40 CM.

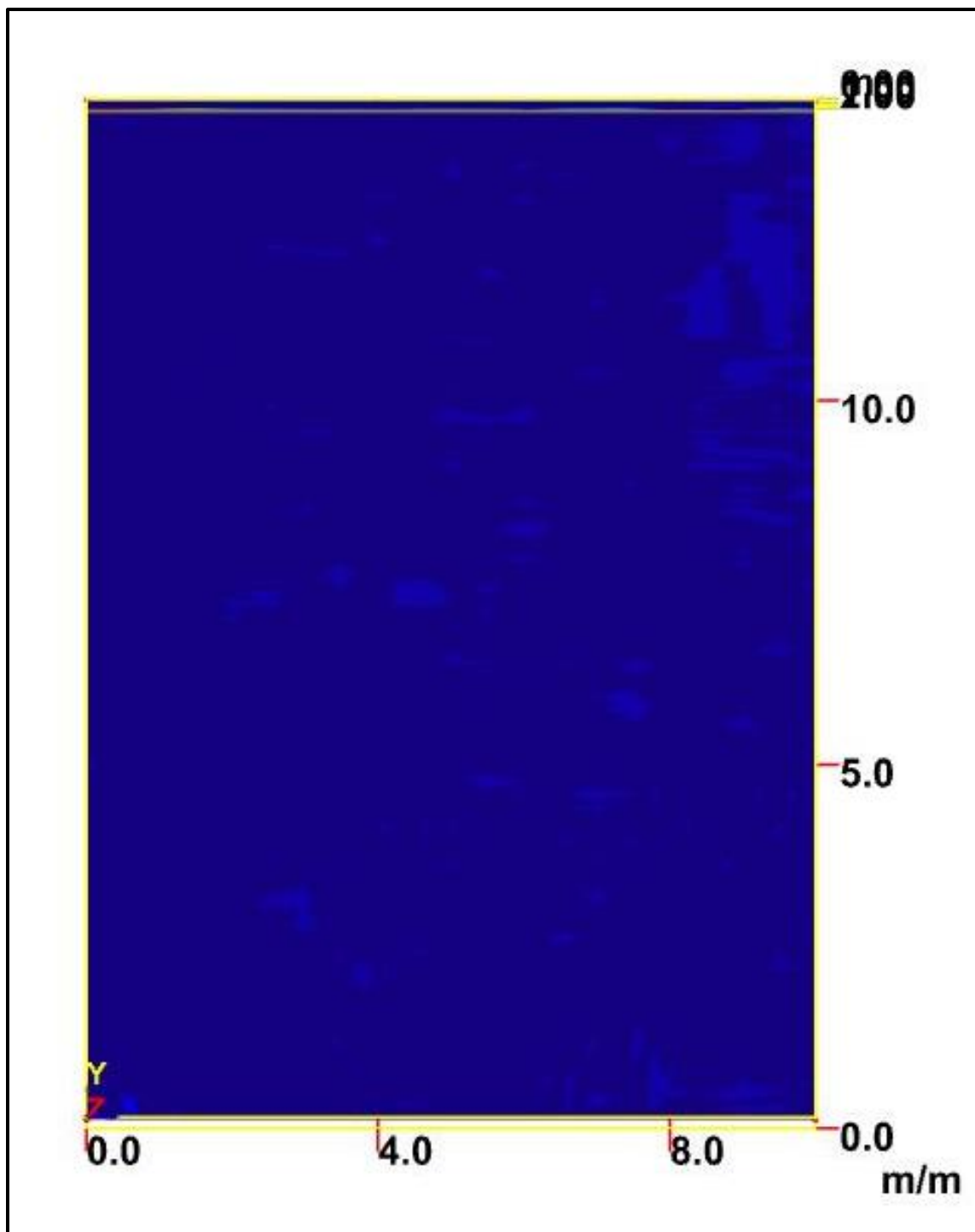


Figure 45: Nottingham Cemetery 50 CM.

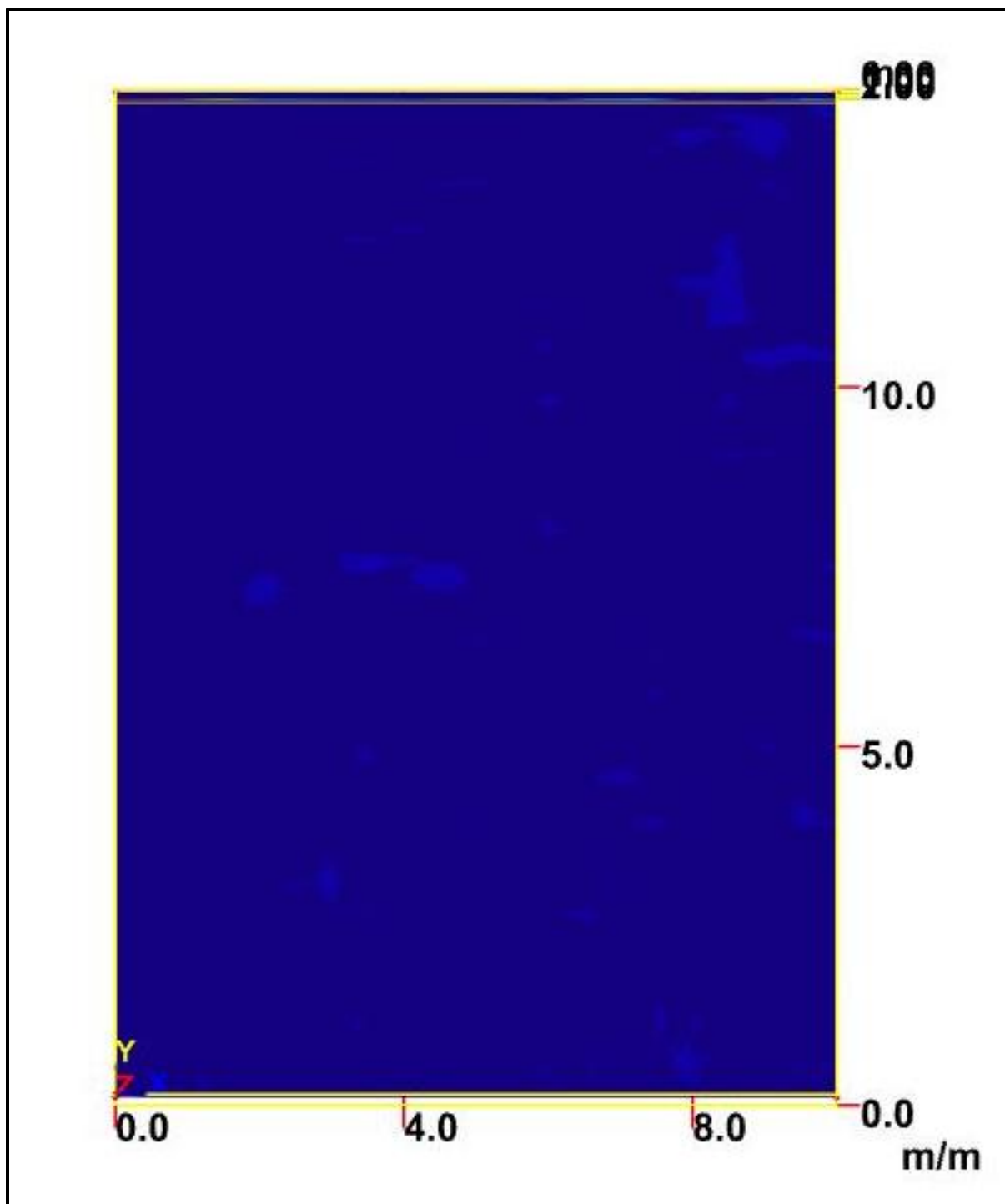


Figure 46: Nottingham Cemetery 60 CM.

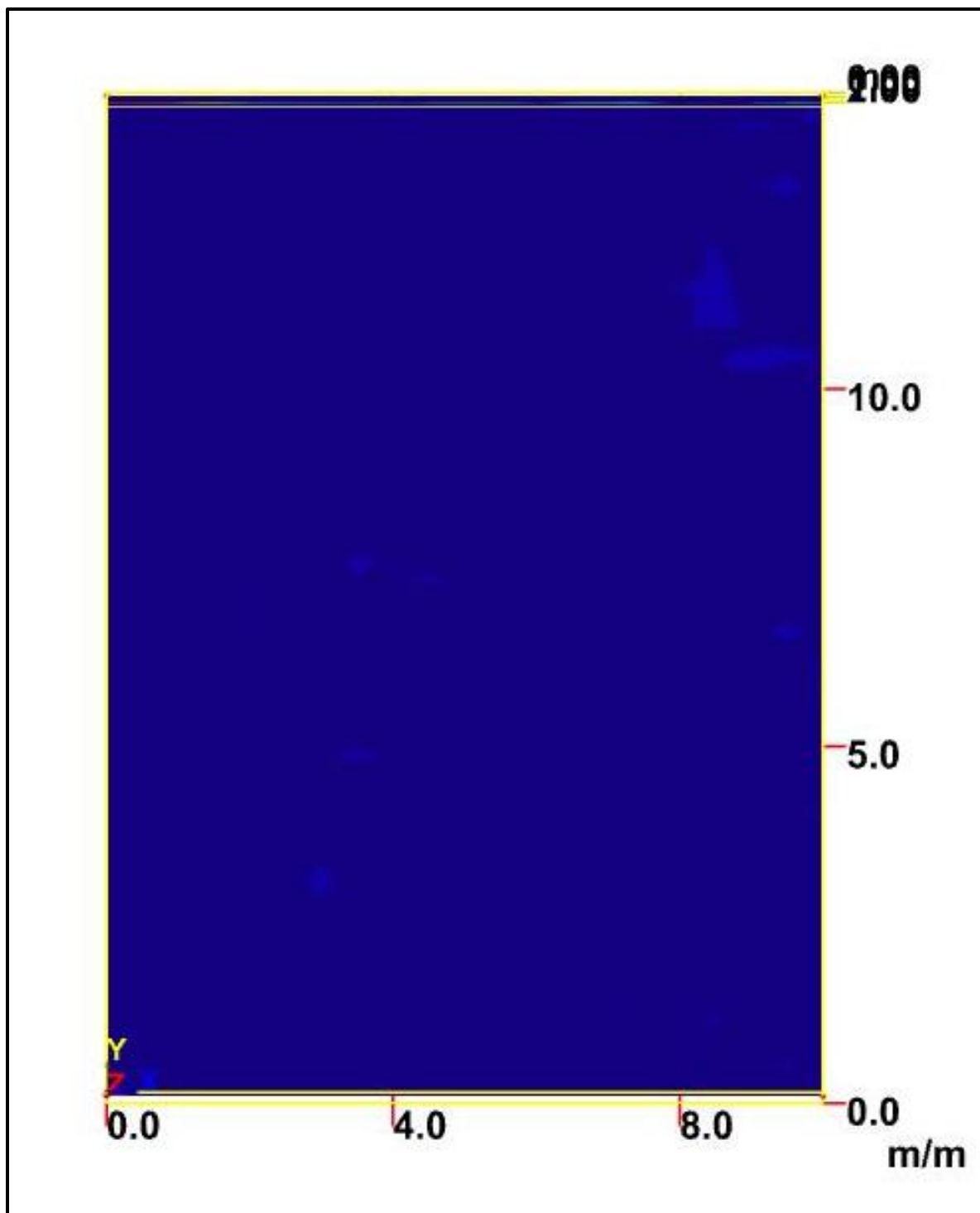


Figure 47: Nottingham Cemetery 70 CM.

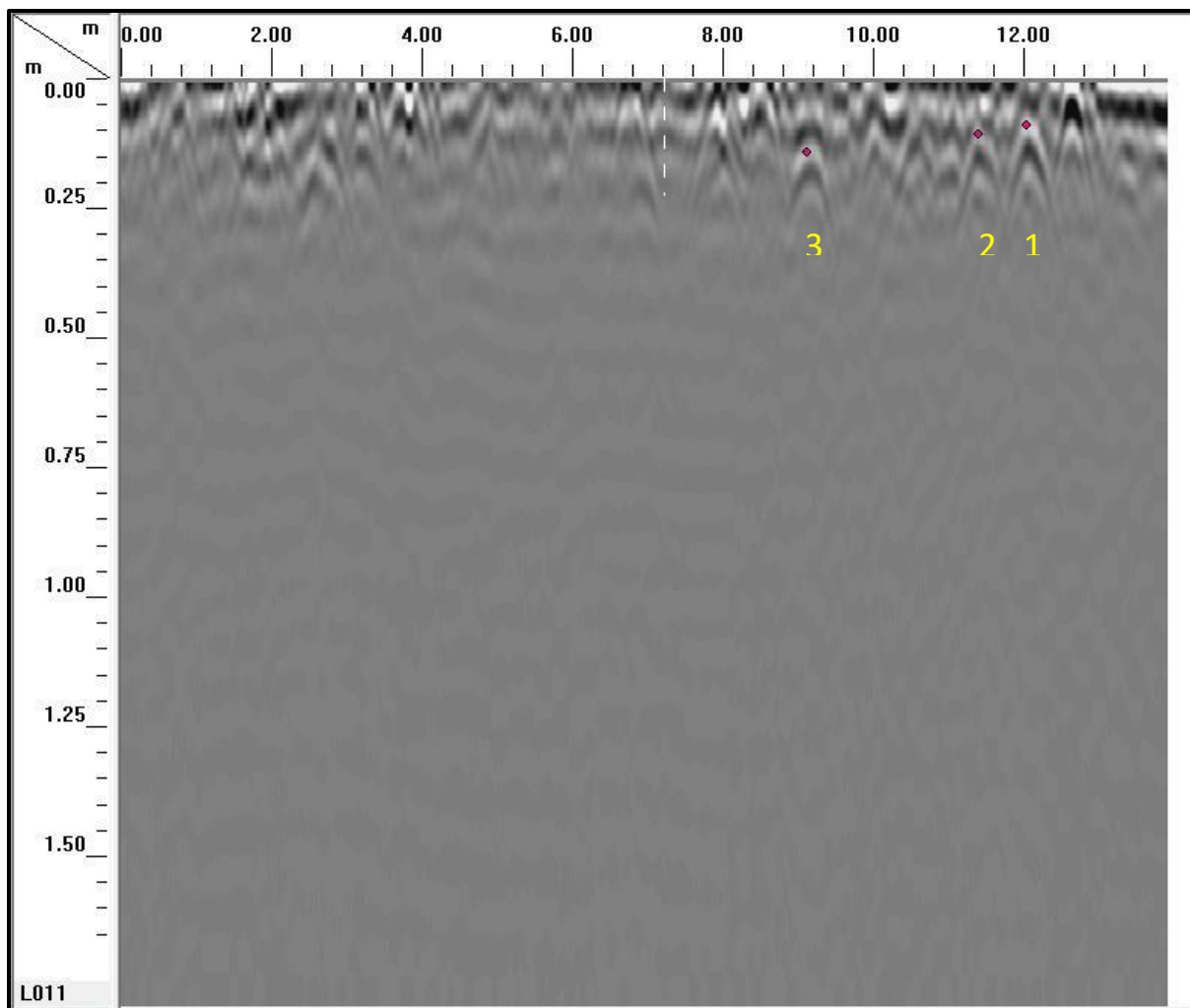


Figure 48: Nottingham Cemetery Transect 11 with Likely Graves 1, 2, and 3 (purple).

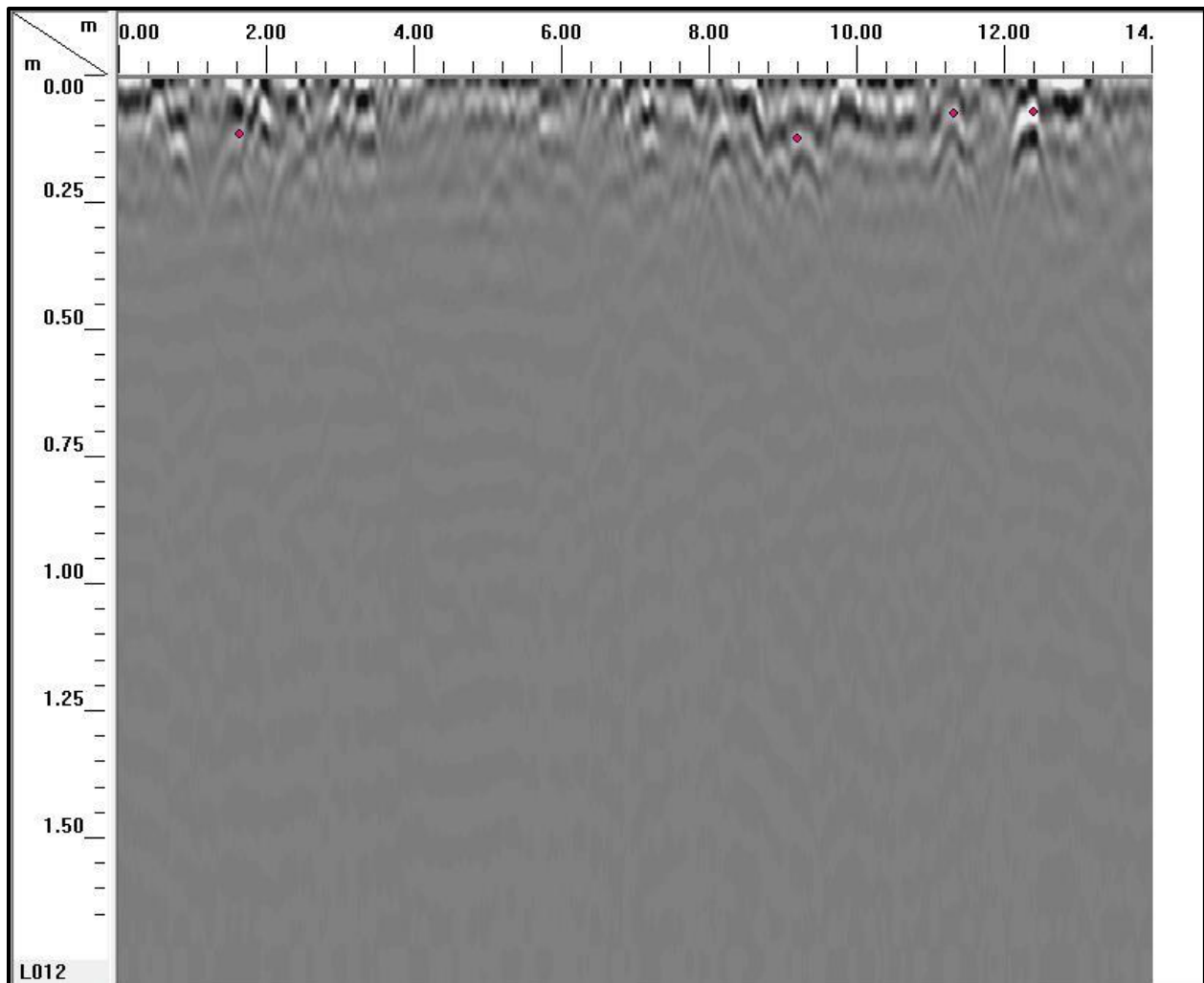


Figure 49: Nottingham Cemetery Transect 12 with Likely Graves 1, 2, and 3 (far right) and Possible Grave 1 (far left).



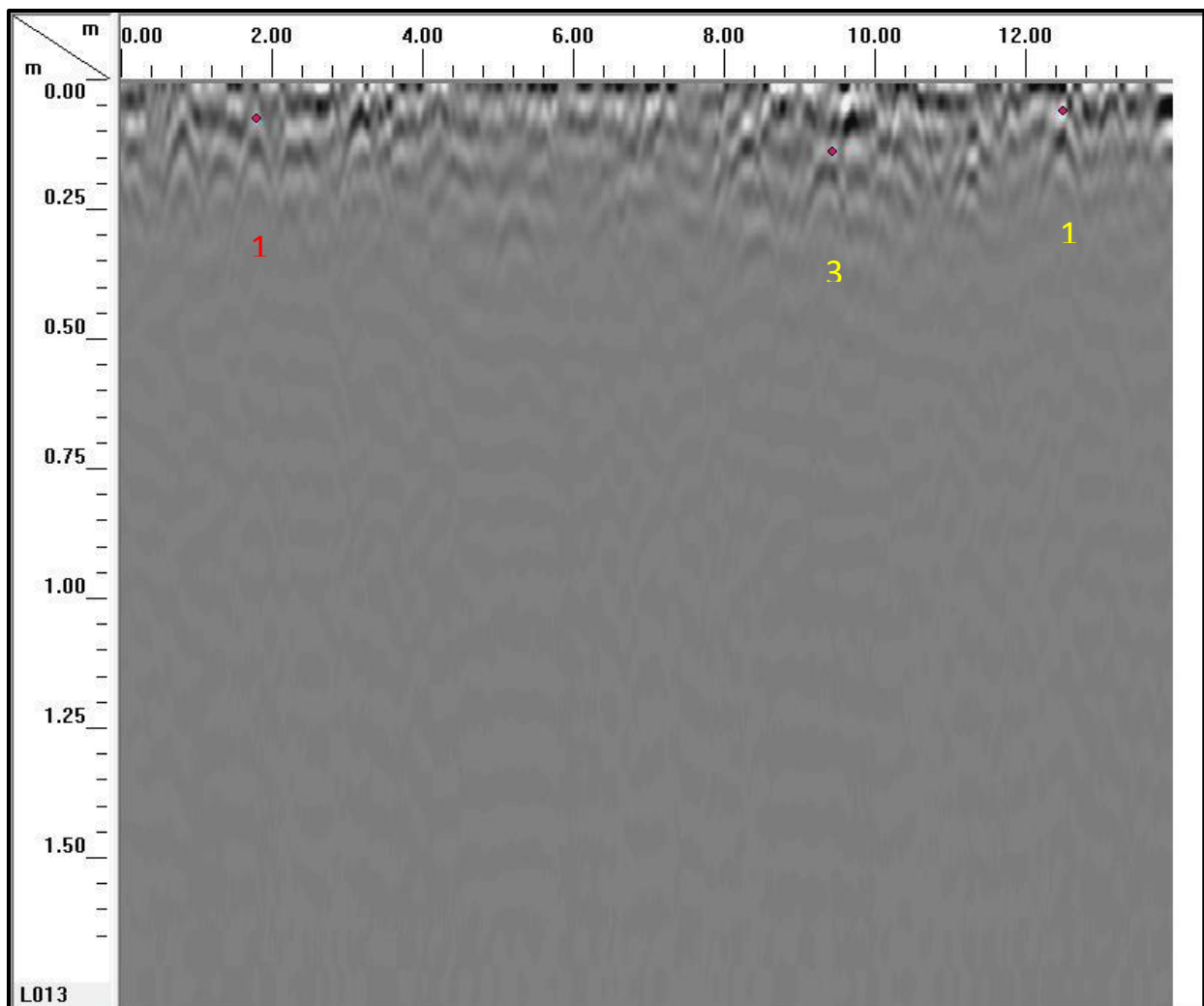


Figure 50: Nottingham Cemetery Transect 13 with Likely Graves 1 and 3 (far right) and Possible Grave 1 (far left).

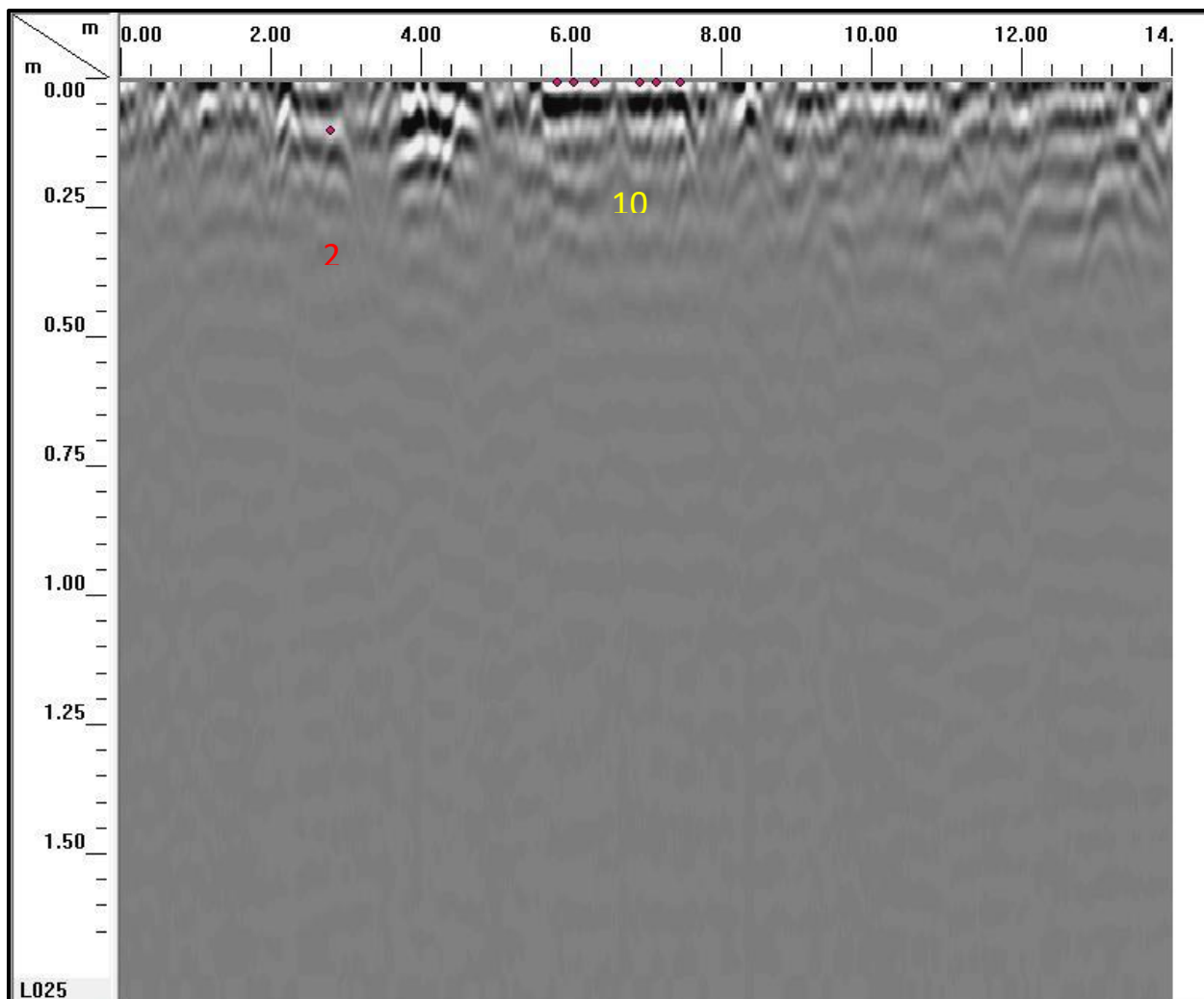


Figure 51: Nottingham Cemetery with Possible Grave 2 and Anomaly 10.

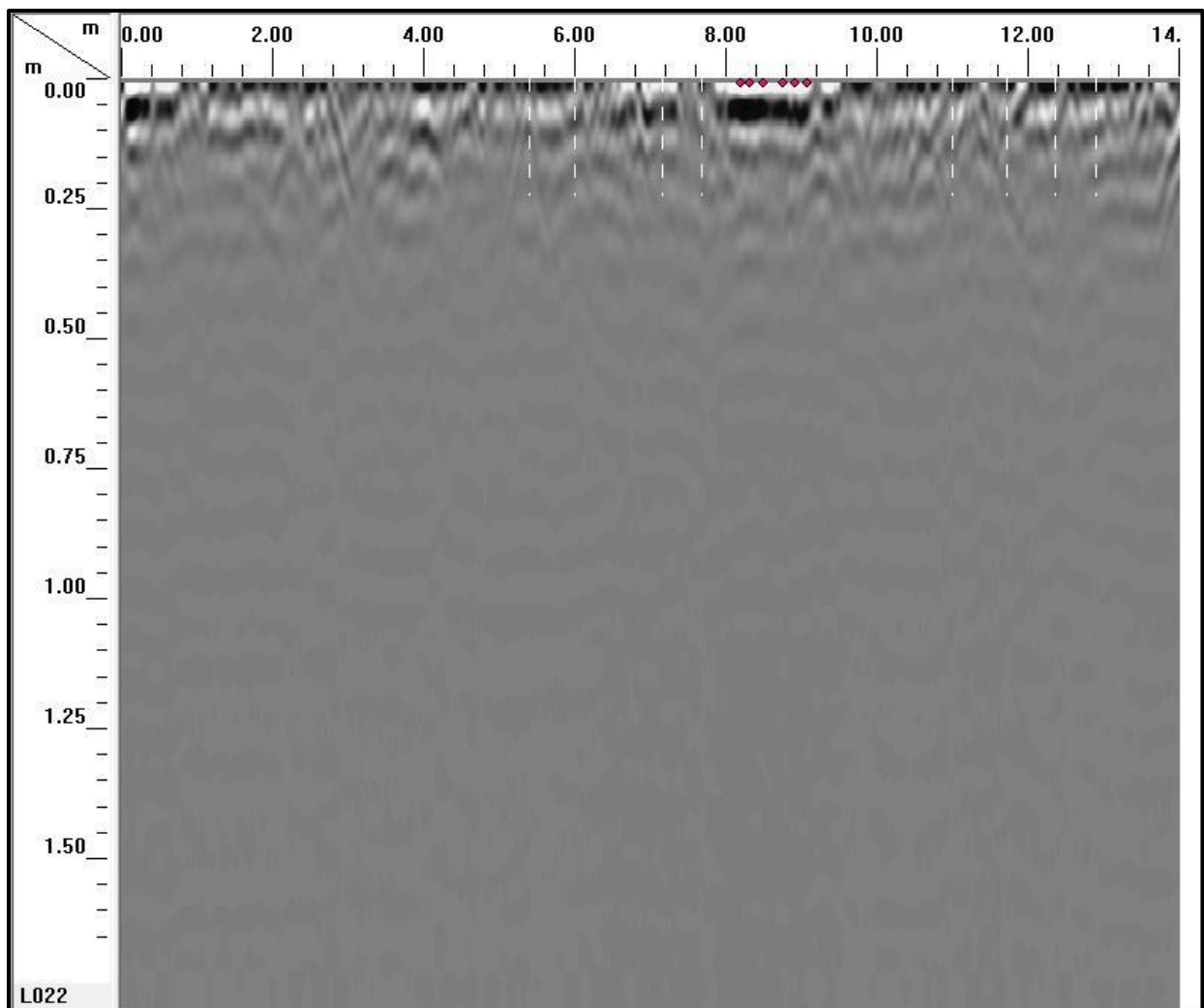


Figure 52: Nottingham Cemetery with Anomaly 10.

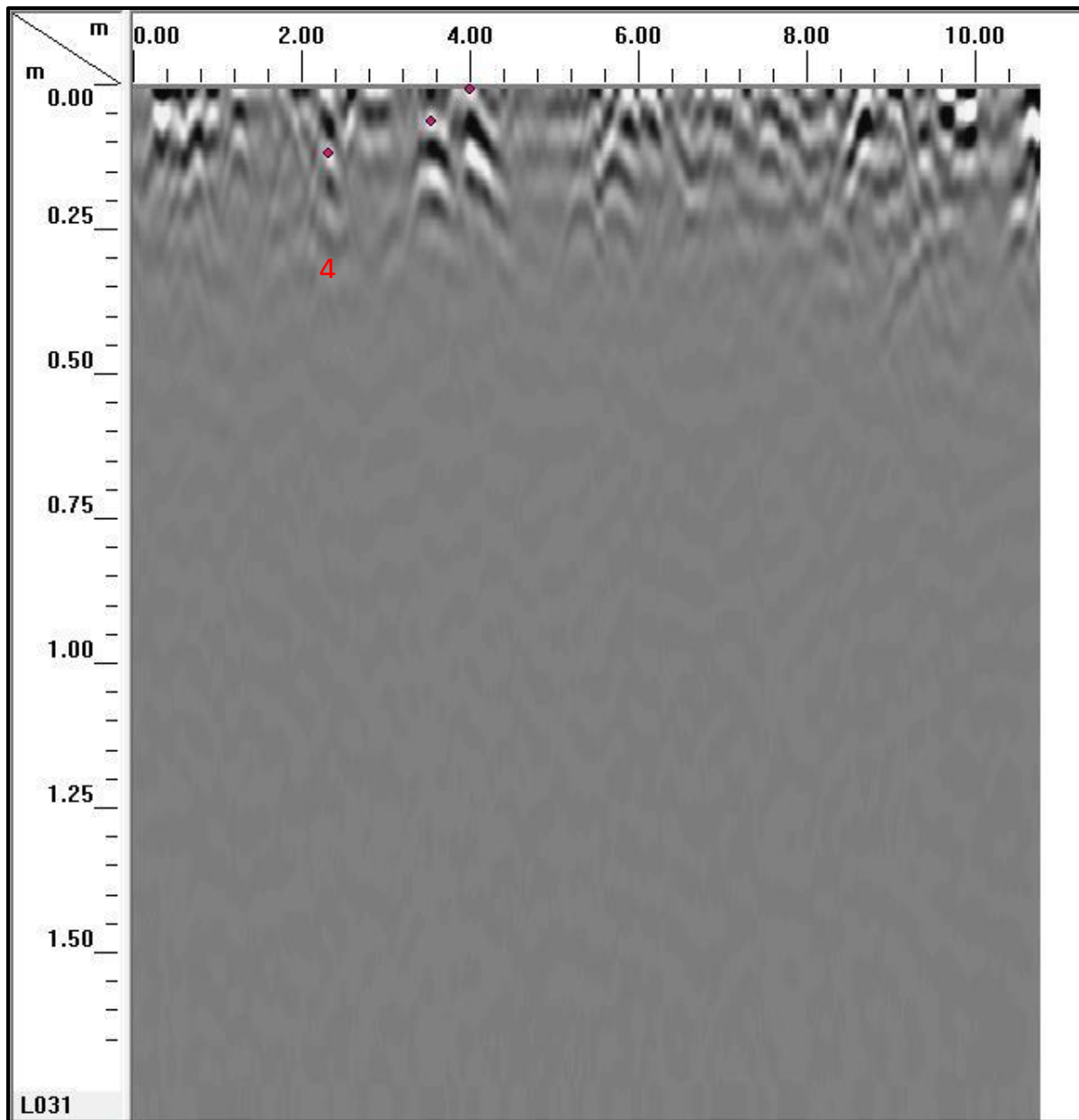


Figure 53: Nottingham Cemetery with Likely Grave 4 (far left) and Anomalies 12 and 13.

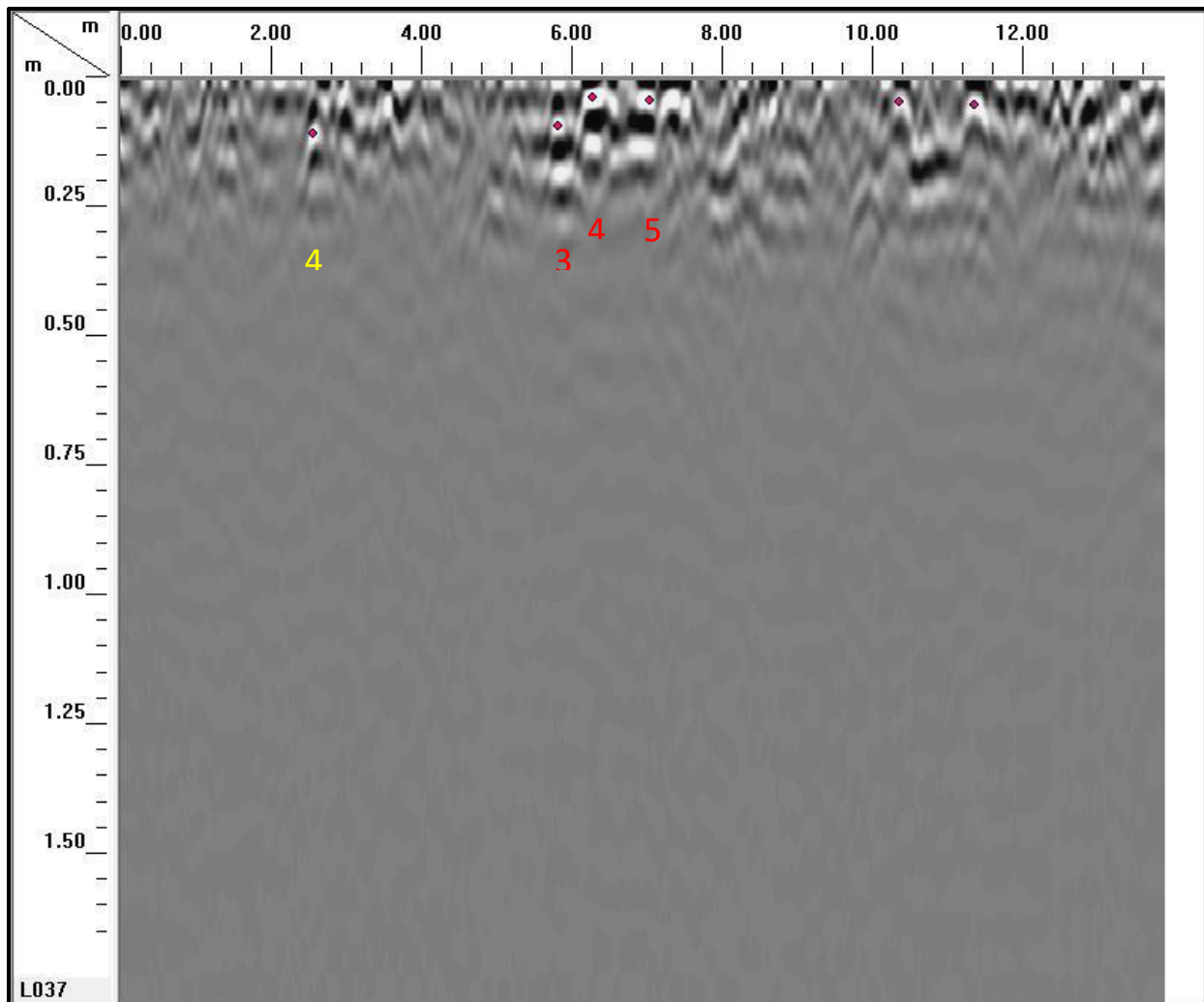


Figure 54: Nottingham Cemetery with Likely Grave 4 (far left), Possible Graves 3, 4, and 5 and Anomalies 12 and 13 (far right).

## Appendix B: Moore-Youse House Time Slices and Radargrams

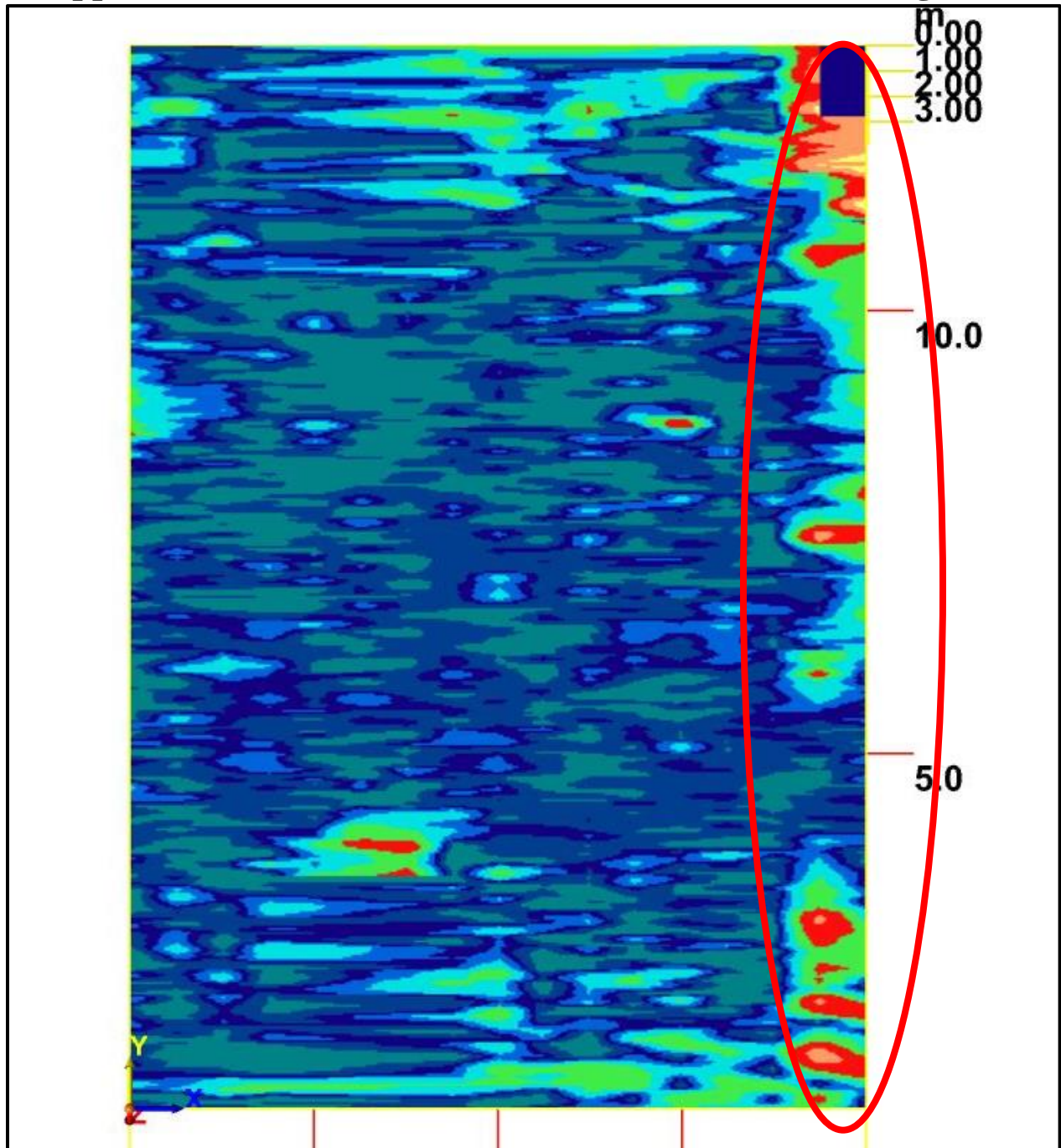


Figure 55: Moore-Youse 0 Depth with Anomaly 1(red).



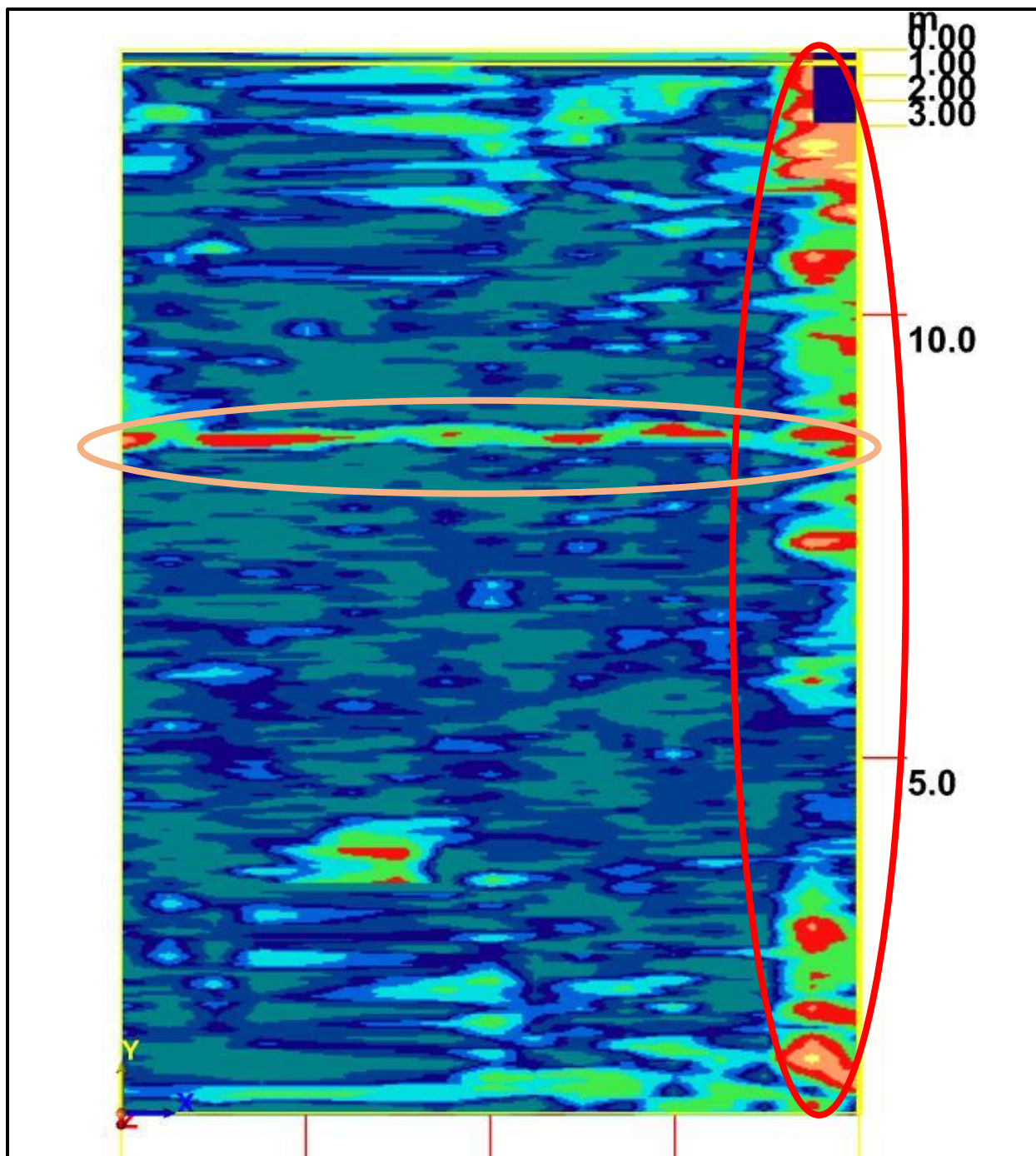


Figure 56: Moore-Youse House 10 CM below Ground Surface with Anomalies 1 (red) and 2 (orange).

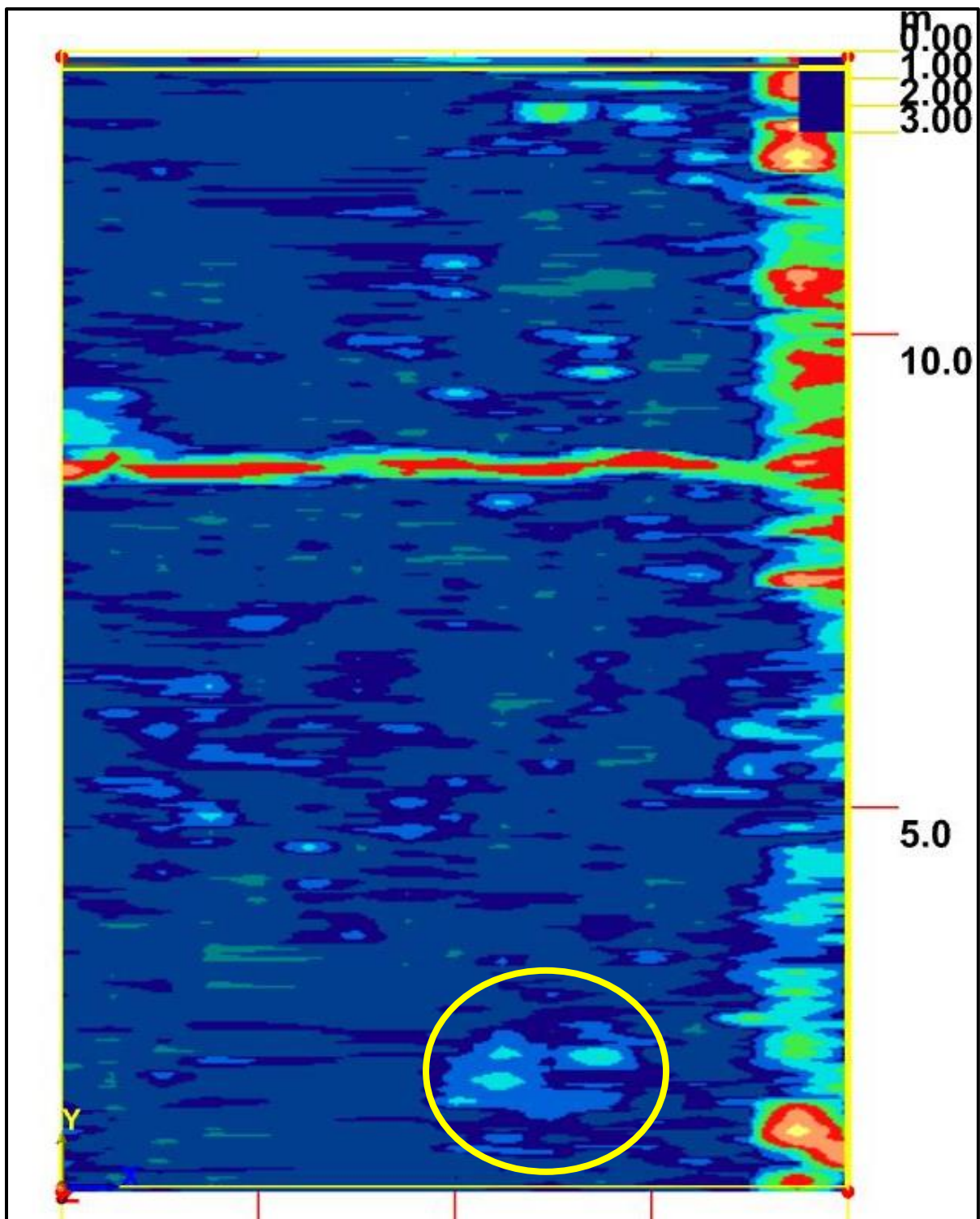


Figure 57: Moore-Youse House 20 CM below Ground Surface with Anomalies 1, 2, and 3 (yellow).



Figure 58: Moore-Youse House 30 CM below Ground Surface with Anomalies 1, 2, and 3 (red).

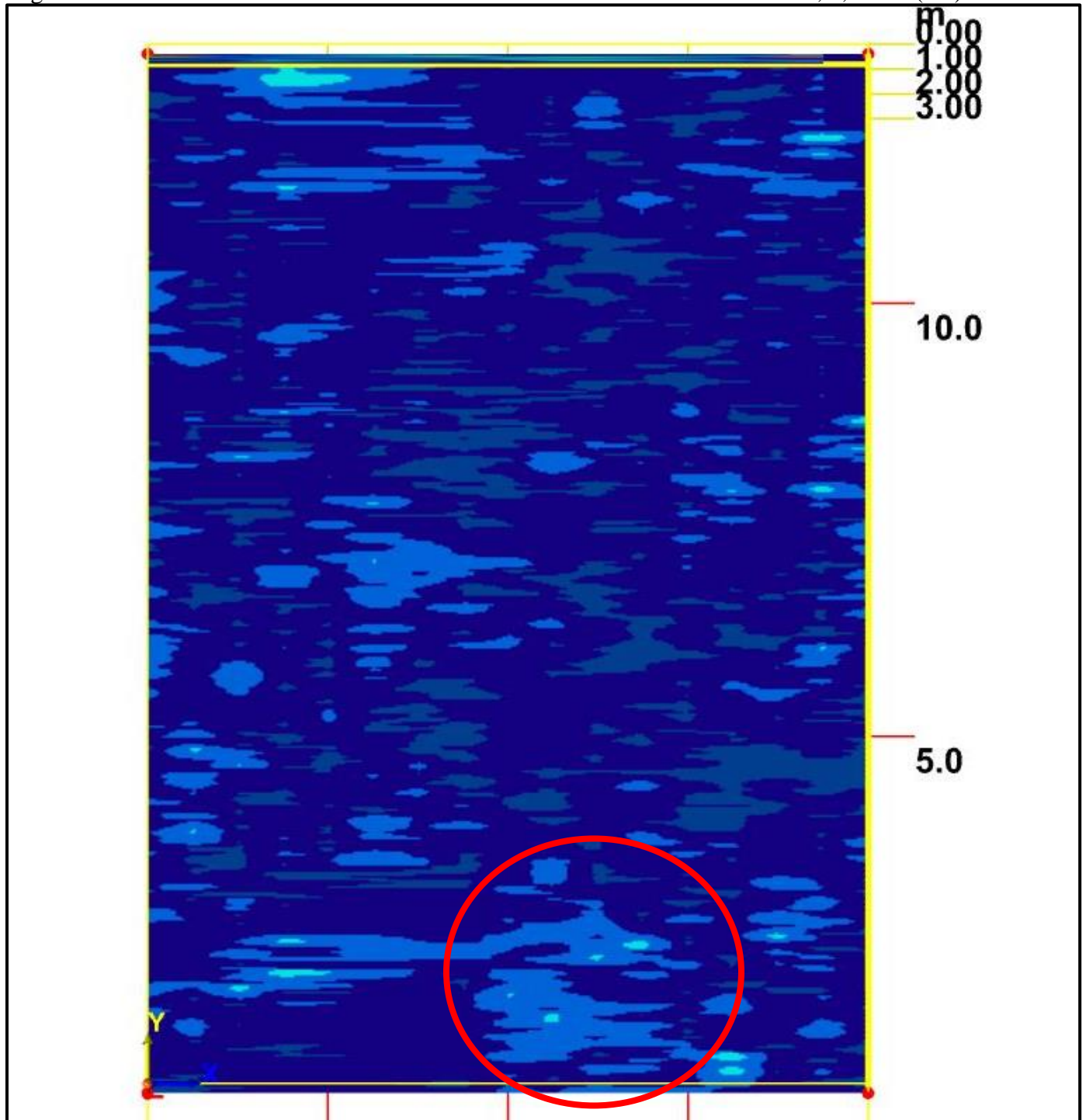


Figure 59: Moore-Youse House 40 CM below Ground Surface with Anomalies 3 (red).

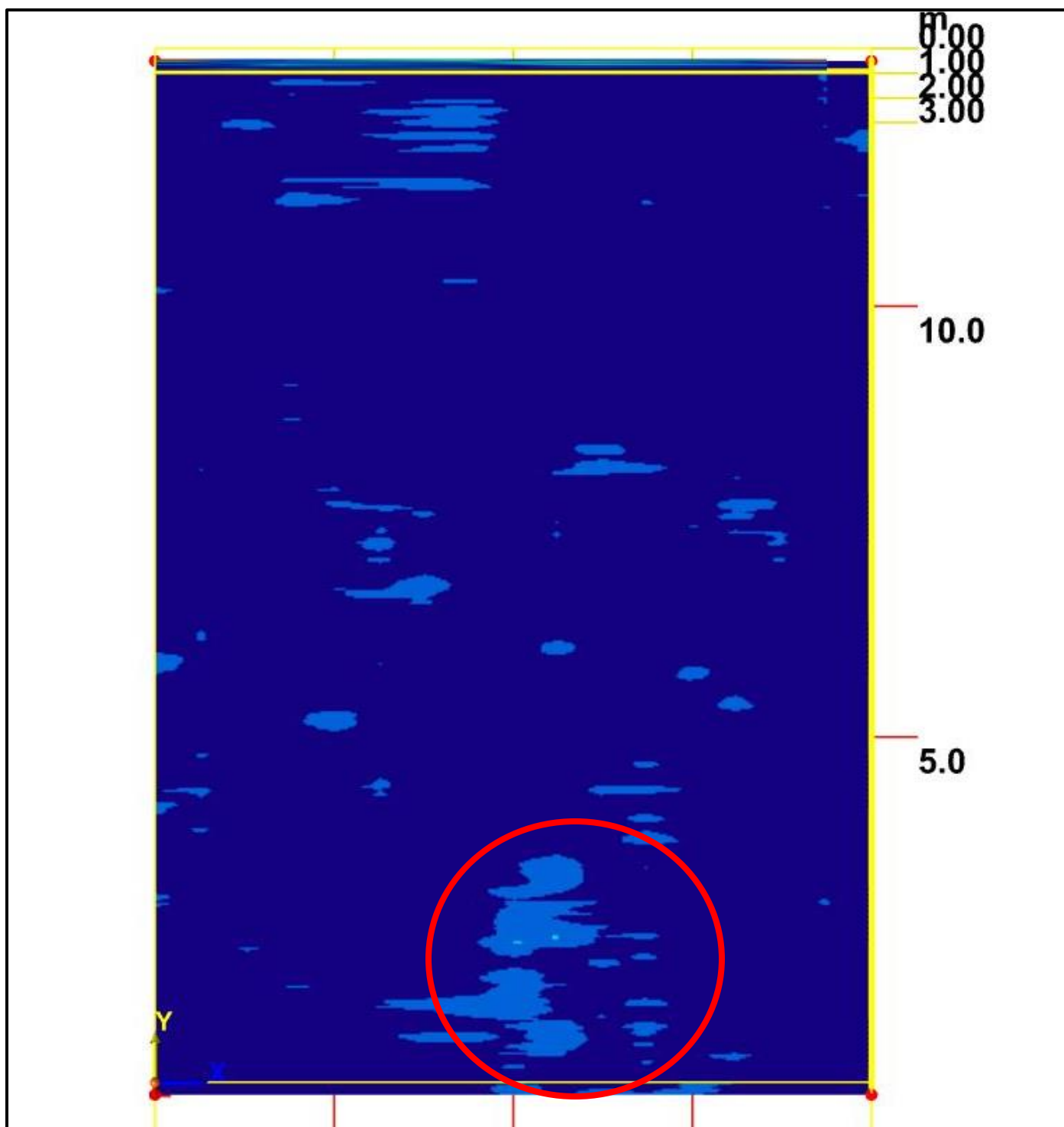


Figure 60: Moore-Youse House 50 CM below Ground Surface with Anomaly 3 (red).

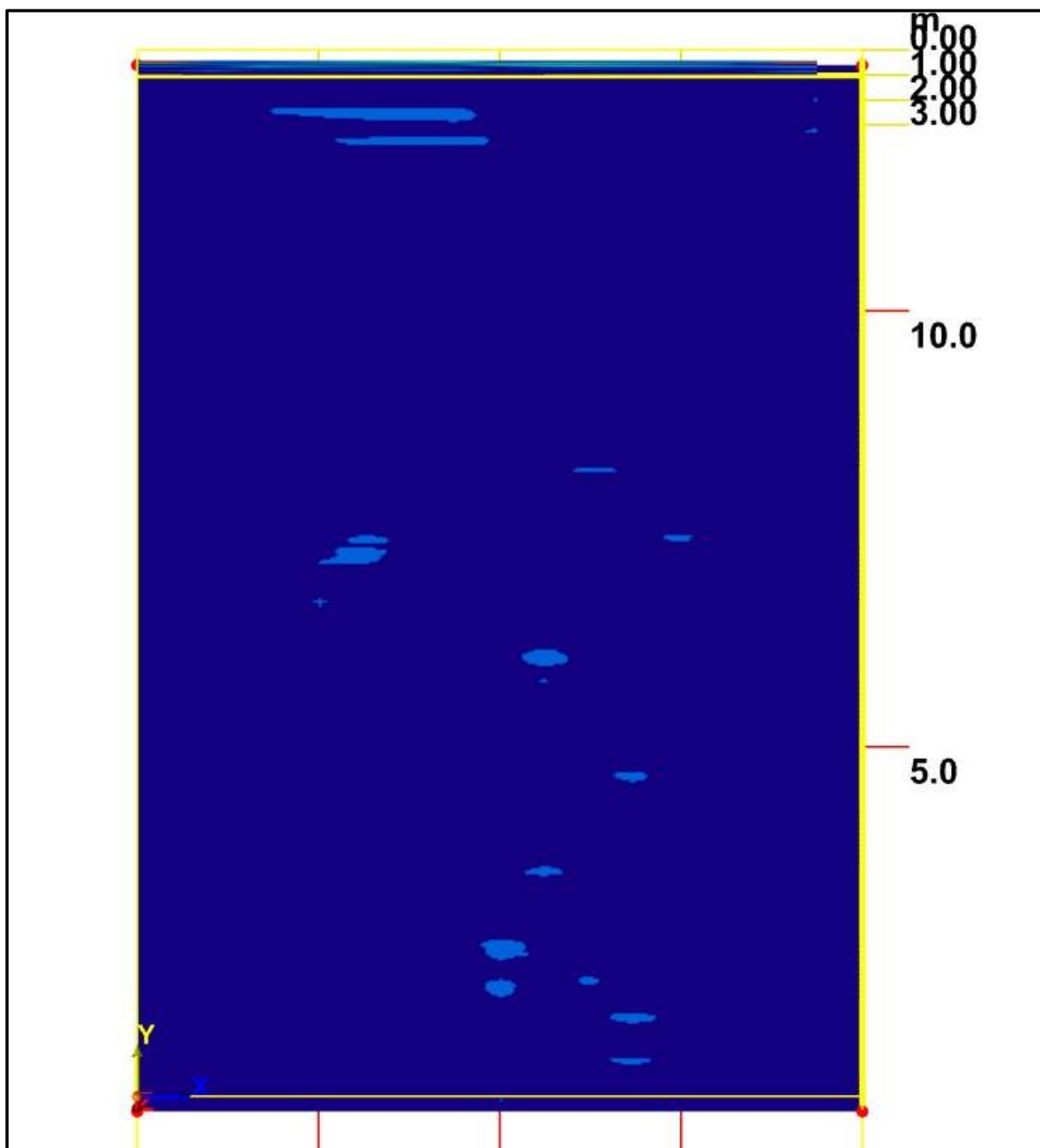


Figure 61: Moore-Youse House 60 CM below Ground Surface.

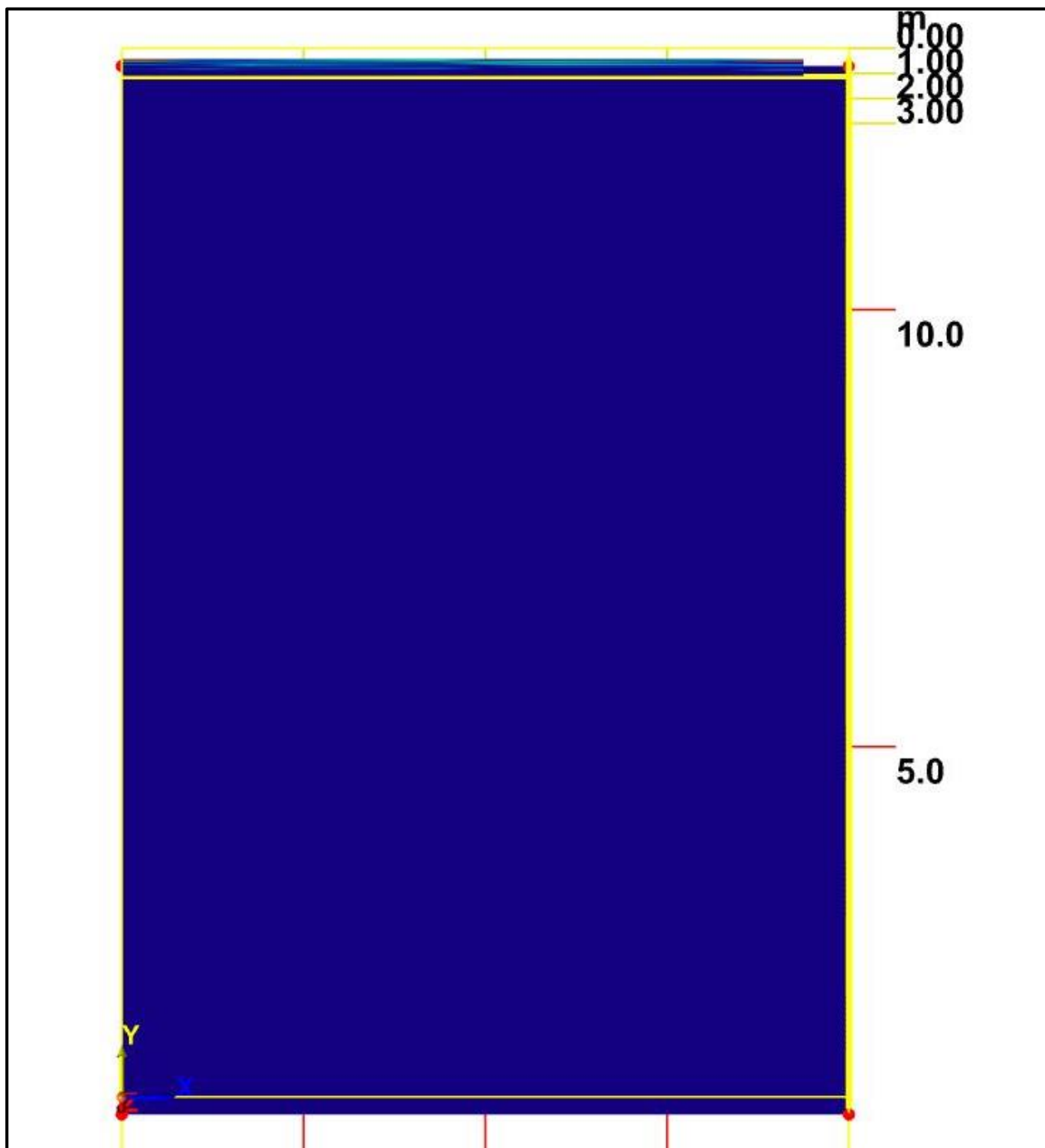


Figure 62: Moore-Youse House 70 CM below Ground Surface.

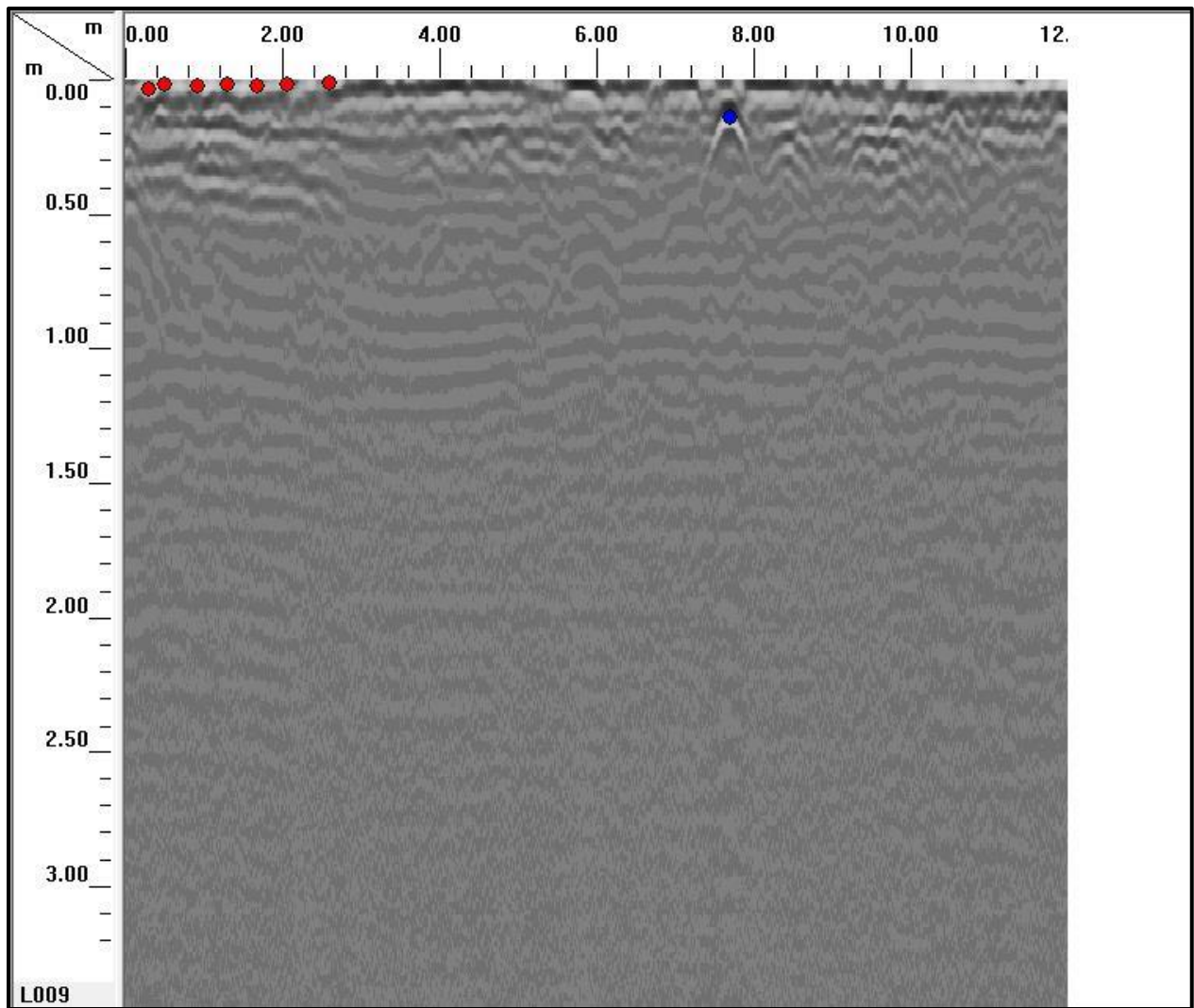


Figure 63: Moore-Youse House Anomaly 2 (Blue) and Anomaly 3 (Red).

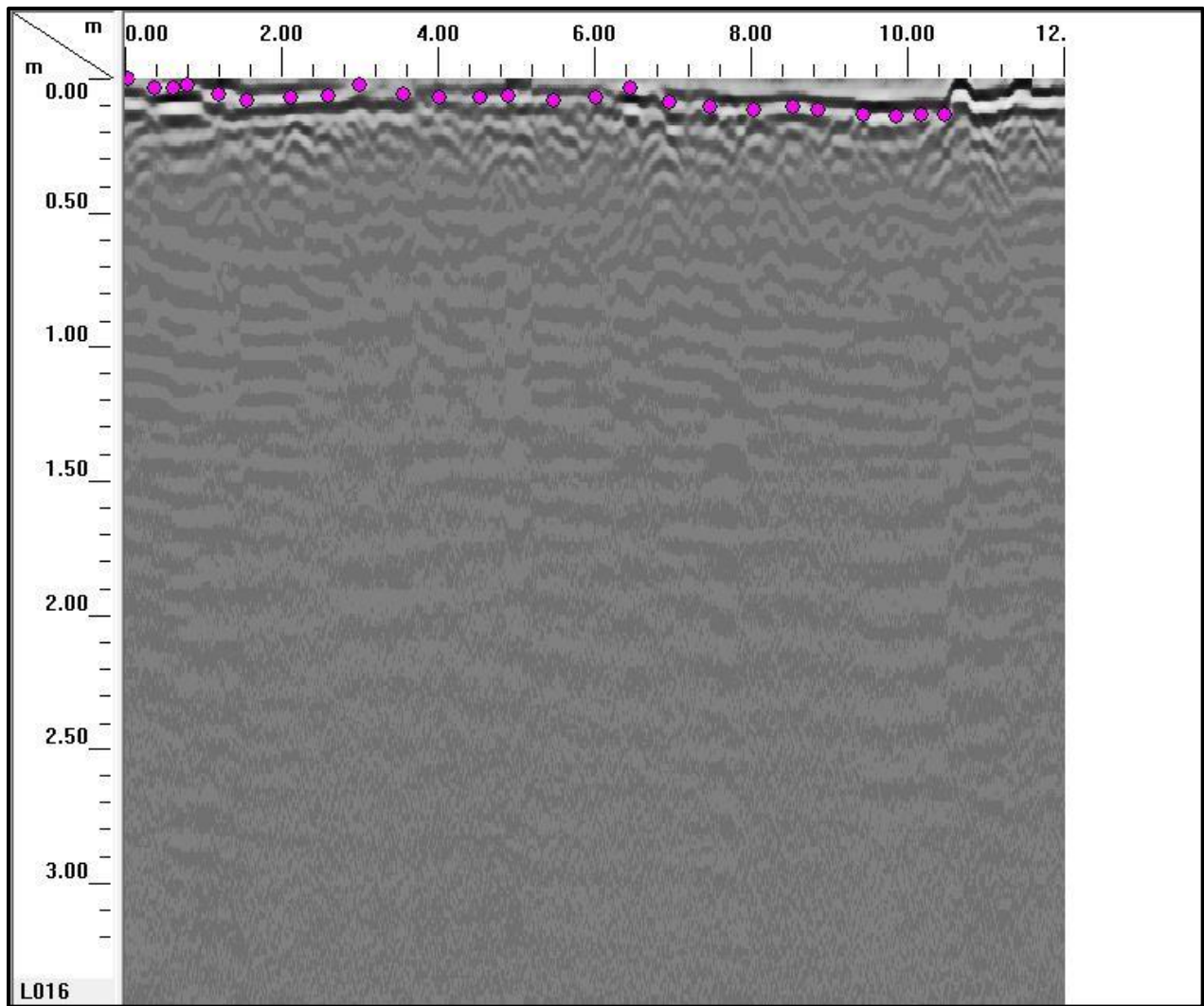


Figure 64: Moore-Youse House Anomaly 1 (Pink).



## Appendix C: McGowan Hall Time Slices and Radargrams.

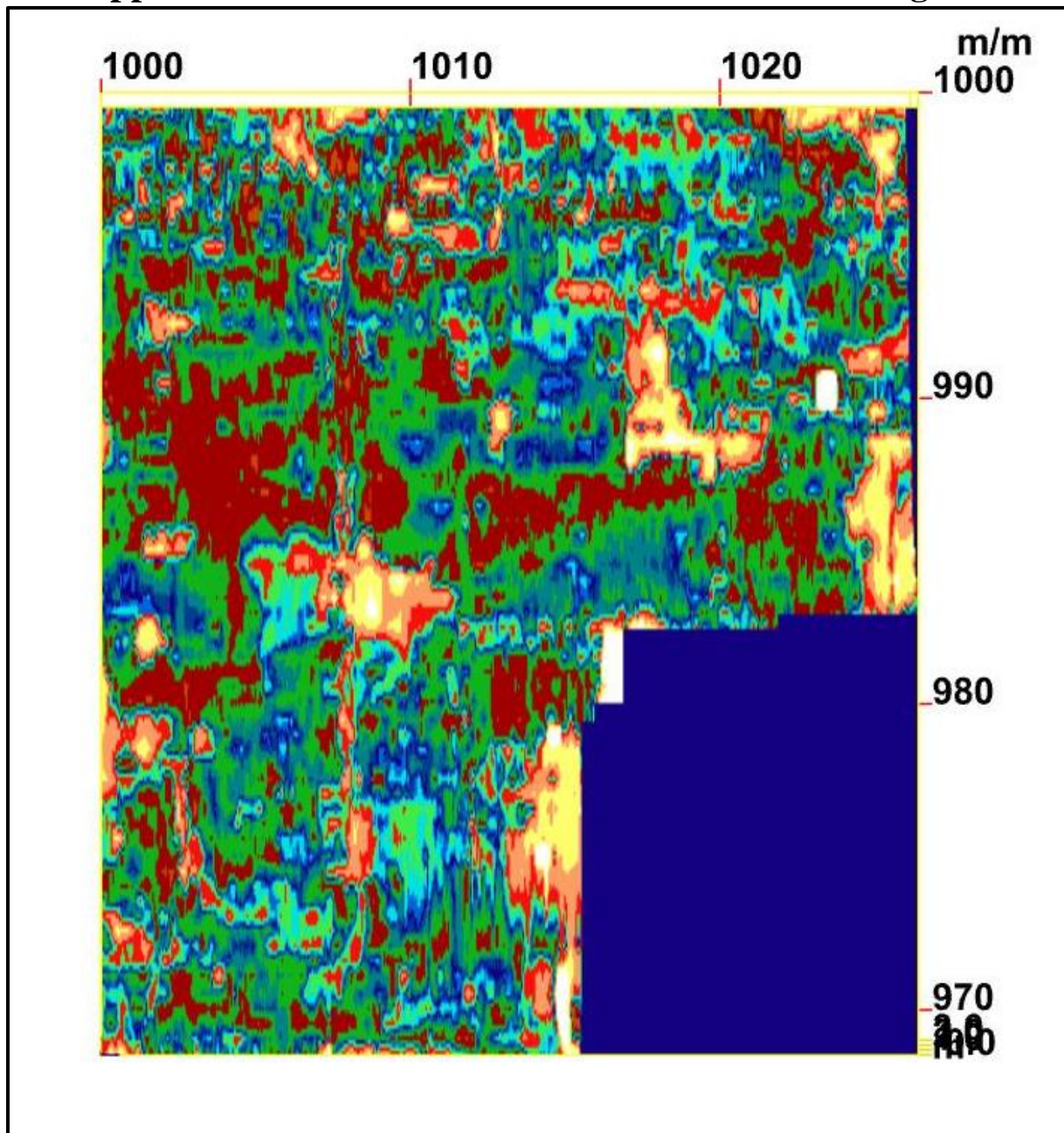


Figure 65: McGowan Hall Ground Surface.

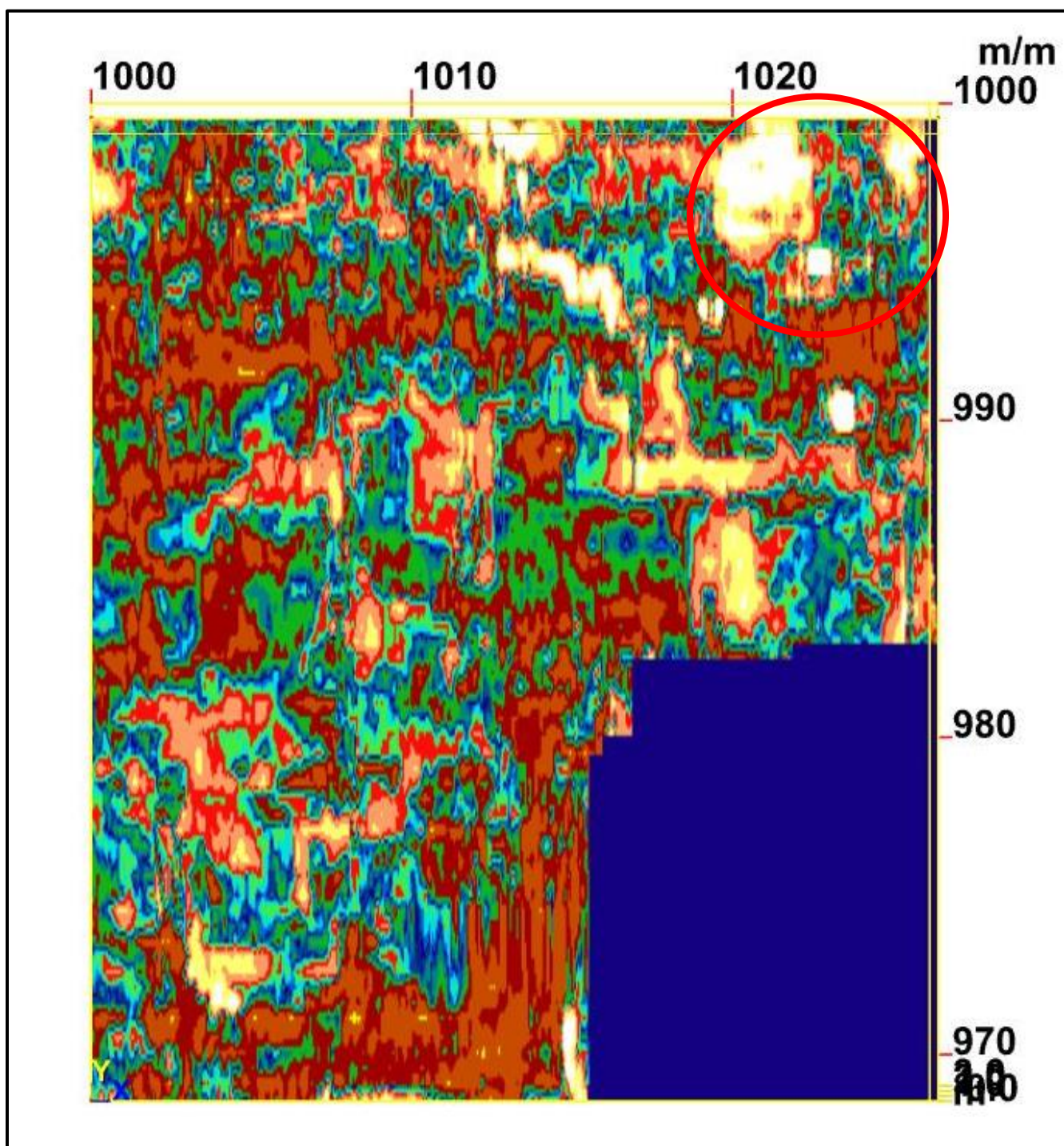


Figure 66: McGowan Hall 15 CM with Anomaly 3 (red).



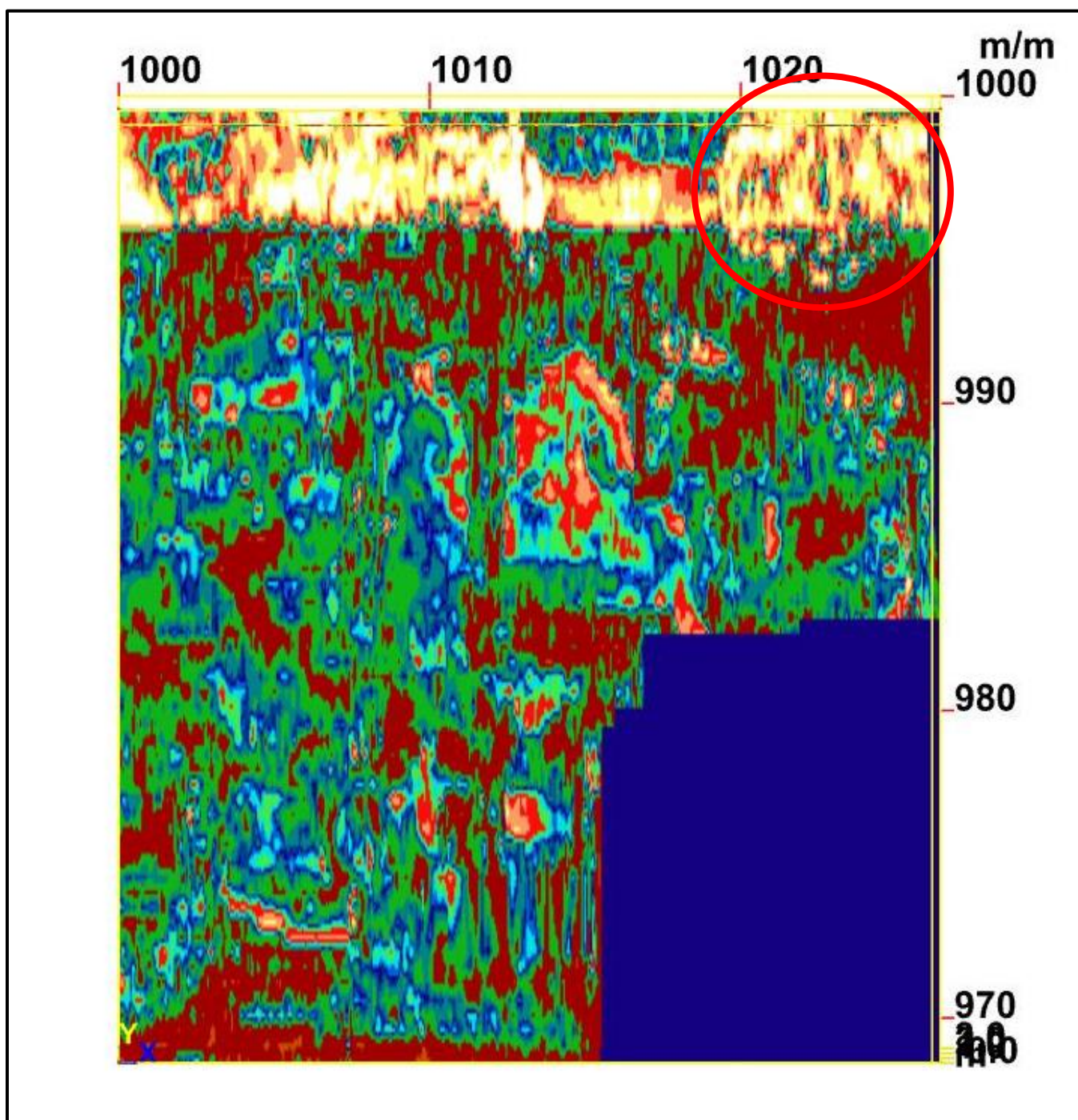


Figure 67: McGowan Hall 28 CM with Anomaly 3 (red).

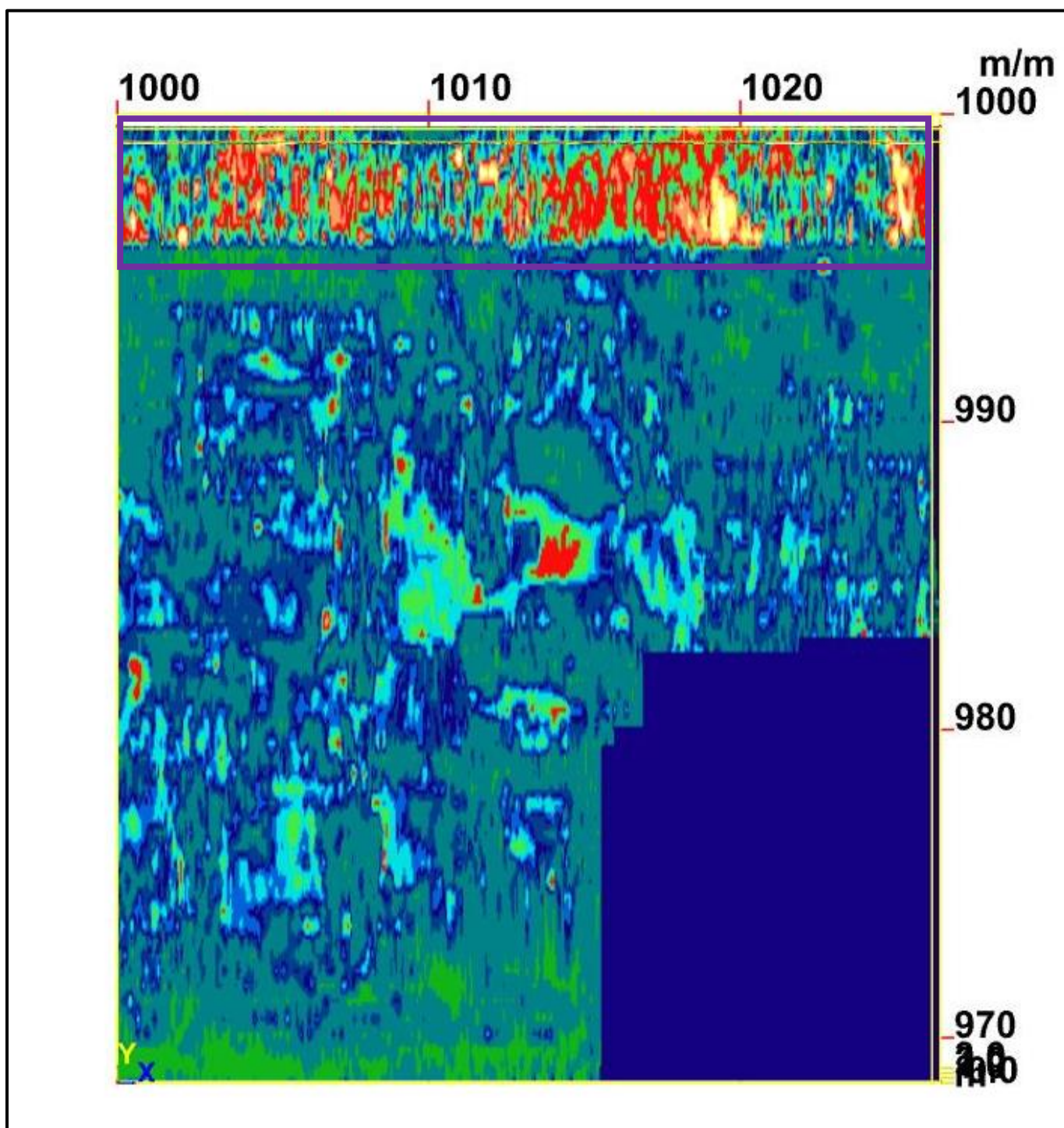


Figure 68: McGowan Hall 45 CM with Anomaly 2 (purple).



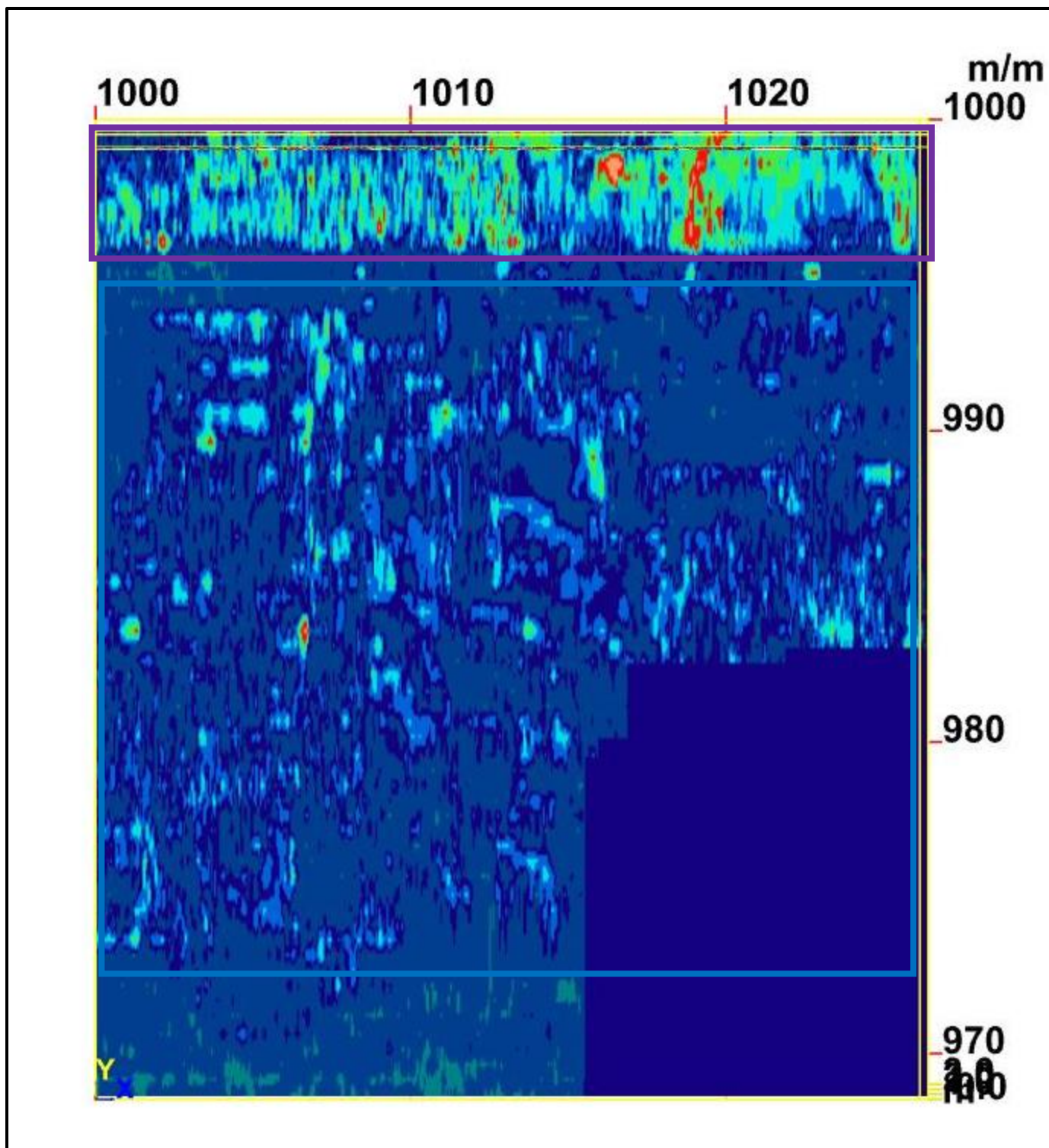


Figure 69: McGowan Hall 60 CM with Anomaly 1 (blue) and Anomaly 2 (purple).

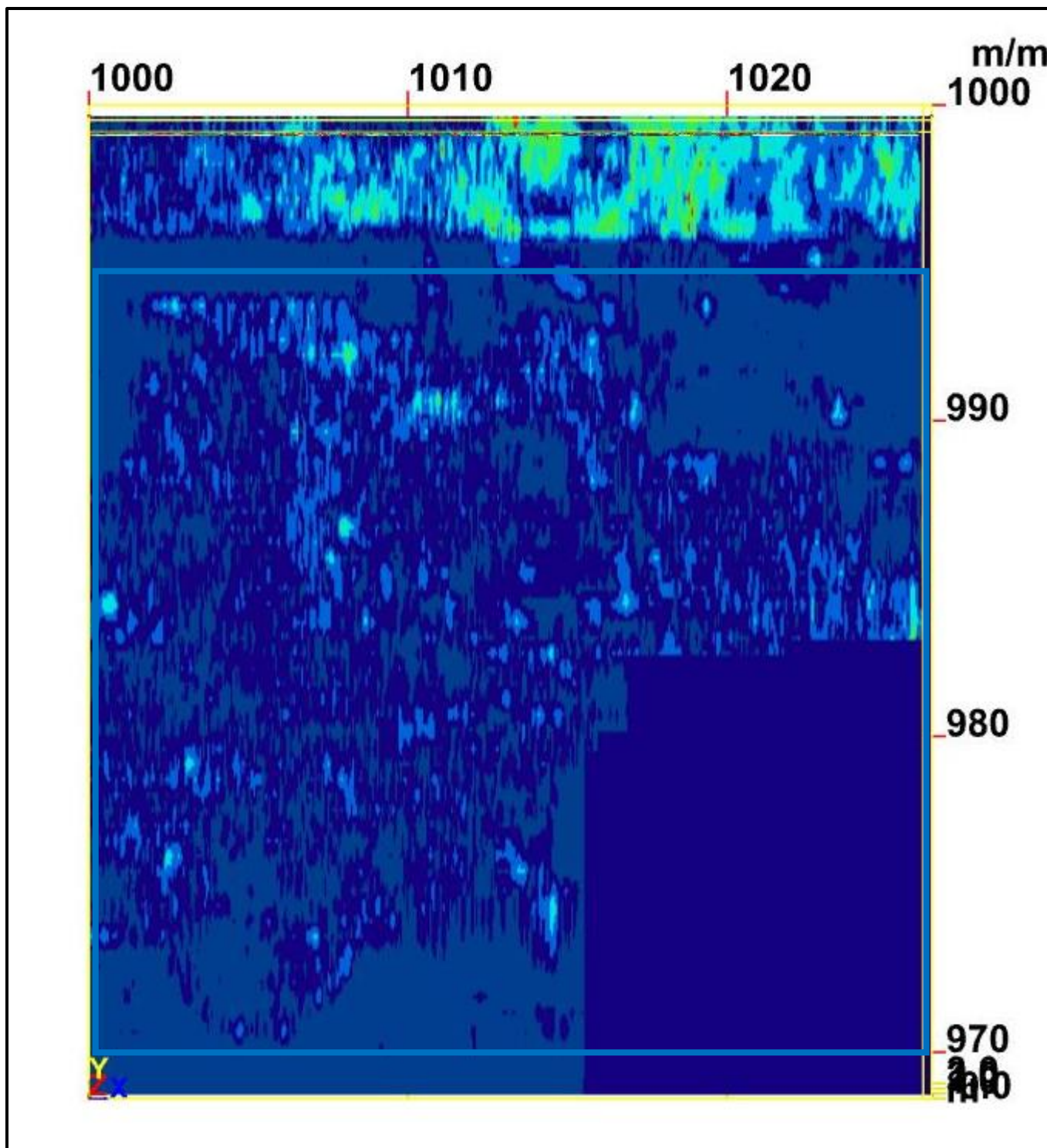


Figure 70: McGowan Hall 75 CM with Anomaly 1 (blue).

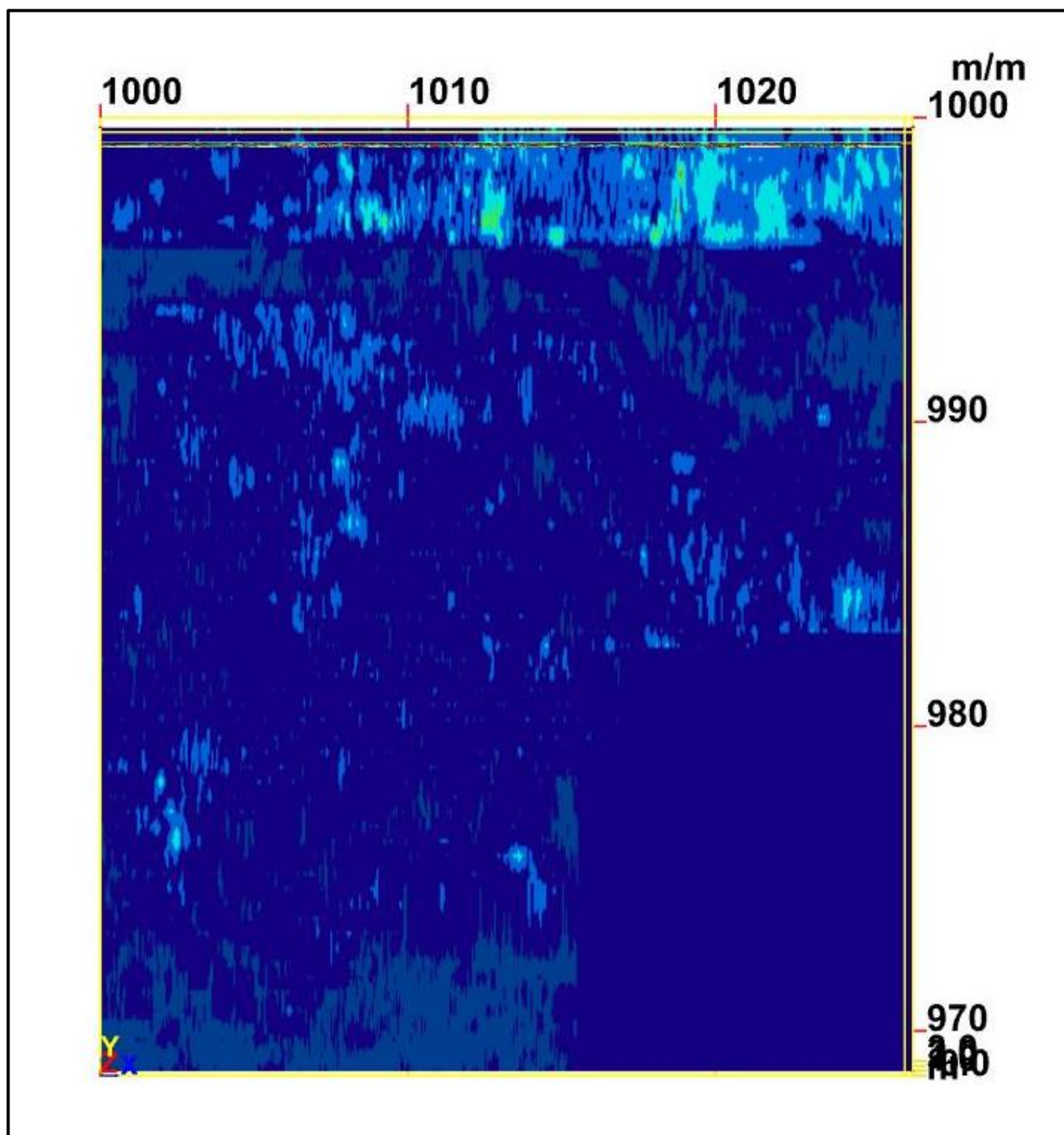


Figure 71: McGowan Hall 90 CM below Ground Surface.



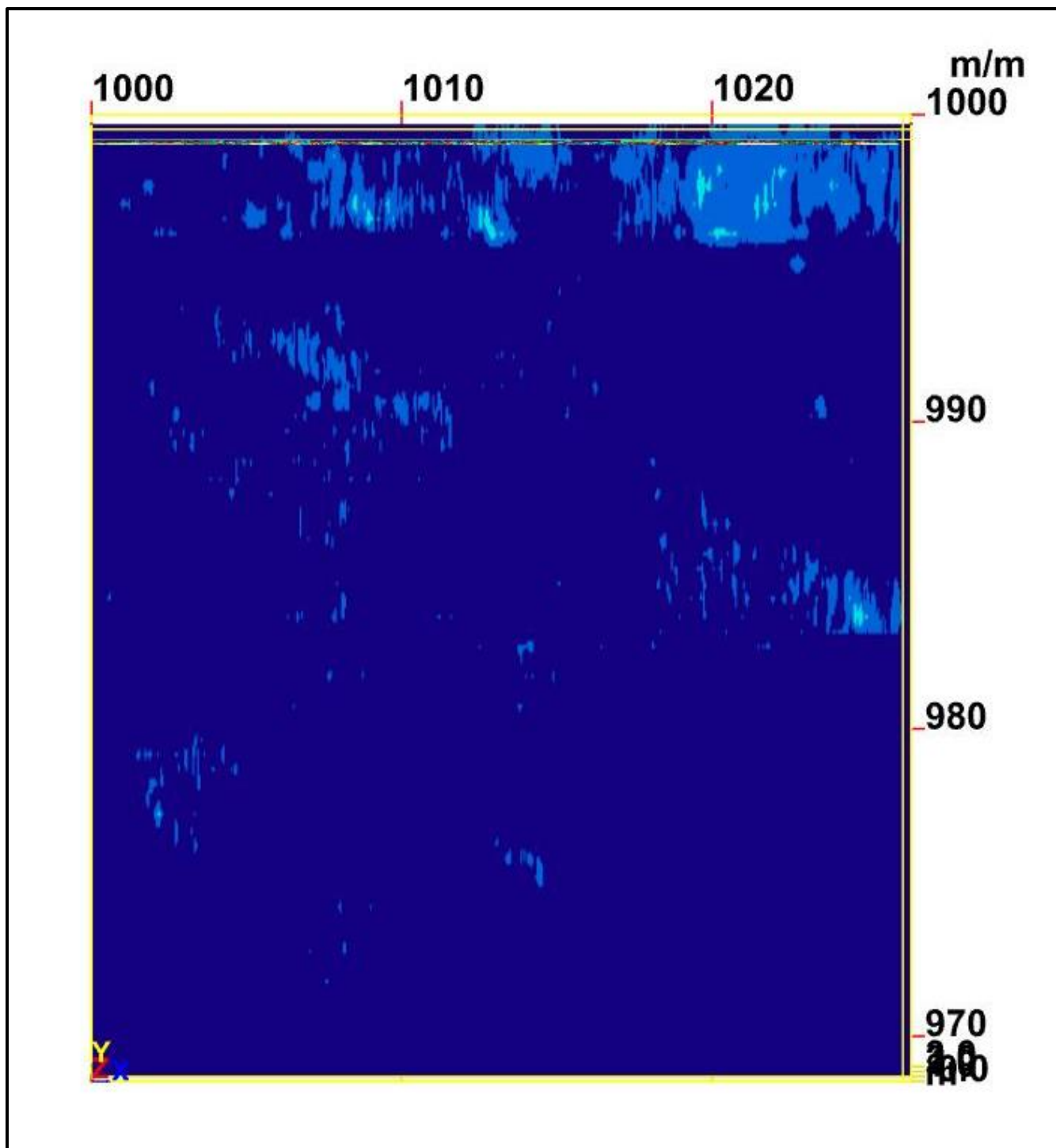


Figure 72: McGowan Hall 105 CM below Ground Surface.

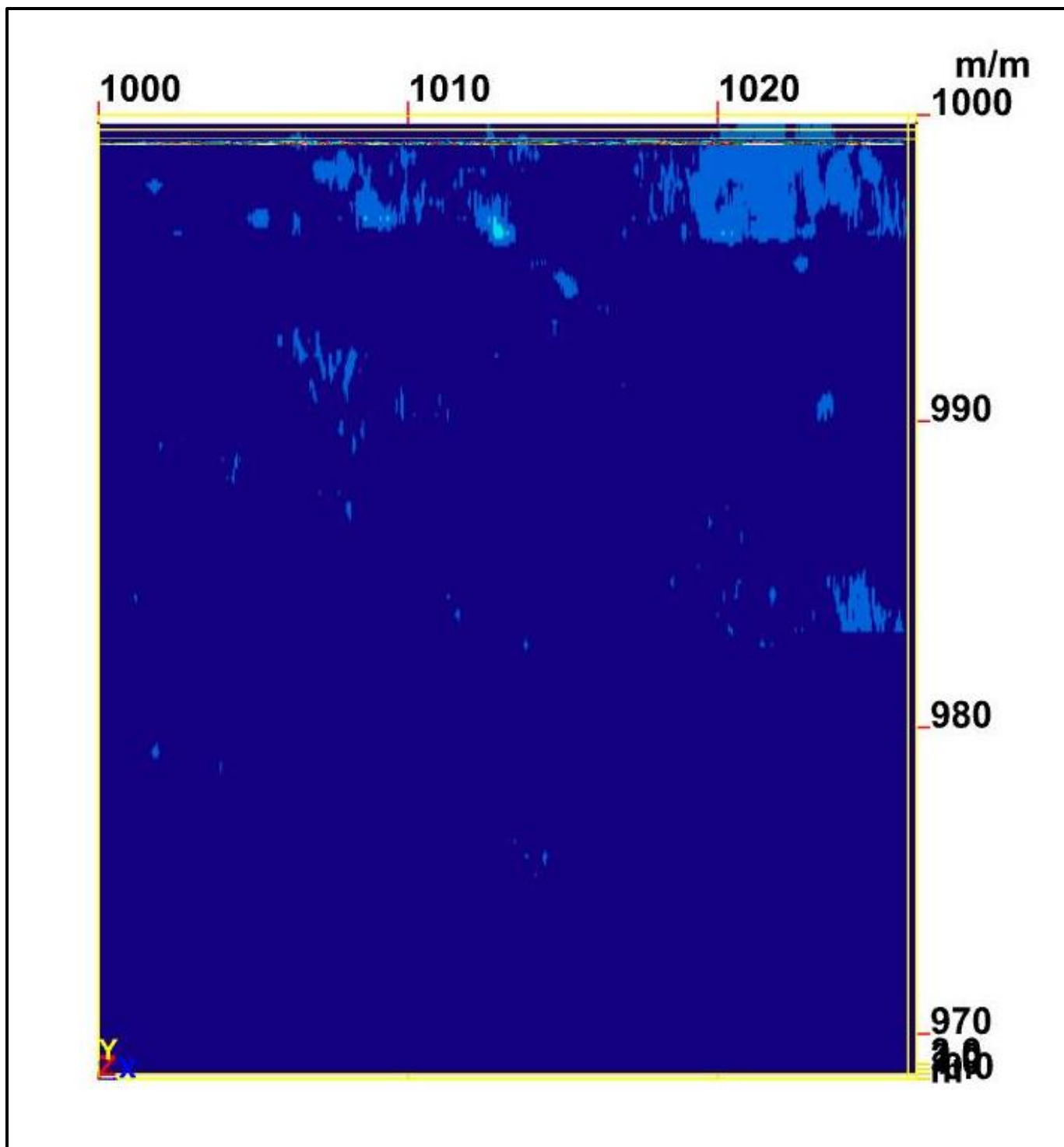


Figure 73: McGowan Hall 120 CM below Ground Level.

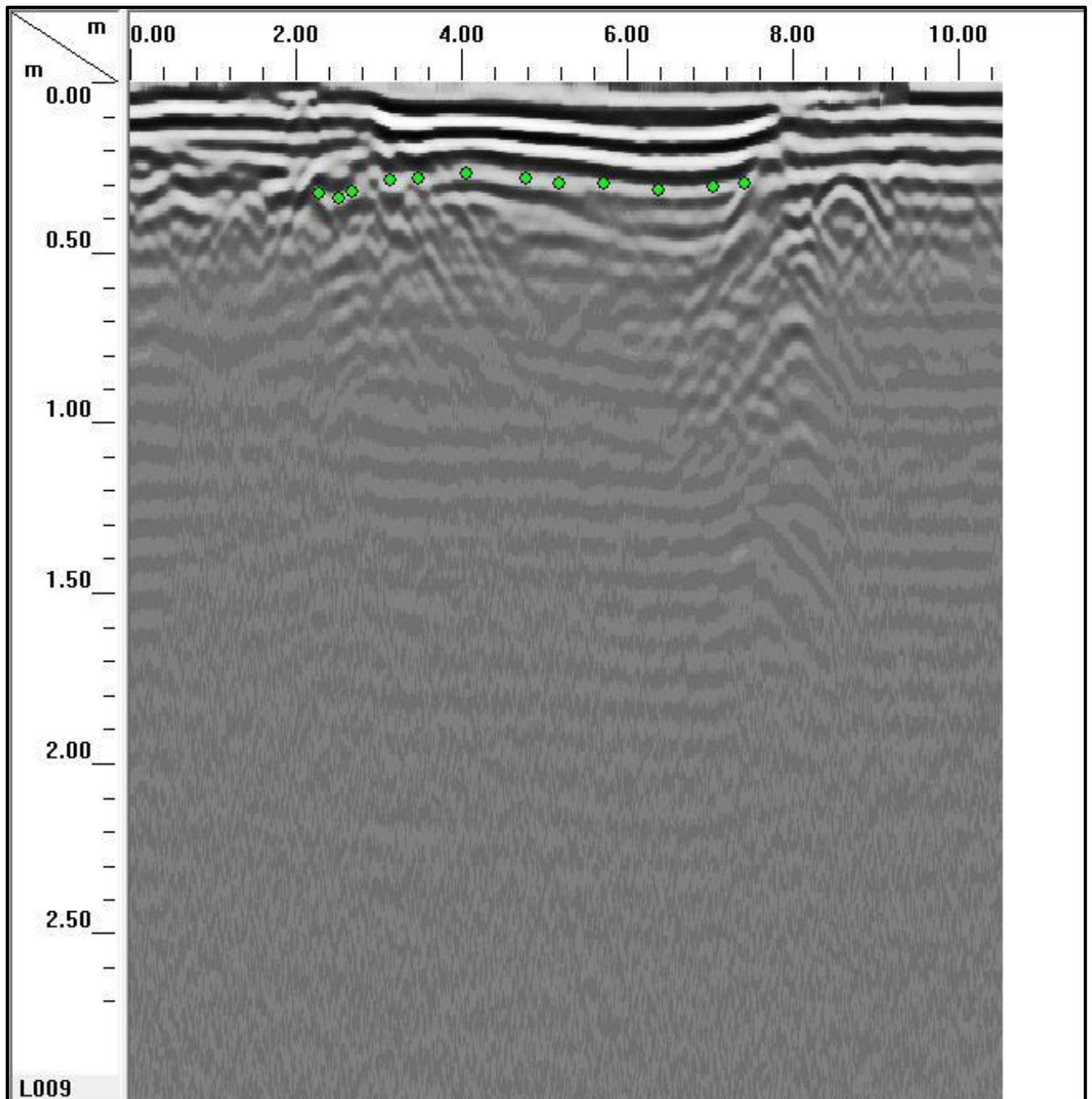


Figure 74: McGowan Hall Anomaly 1 displayed from 2.0 meters to 8.0 meters.



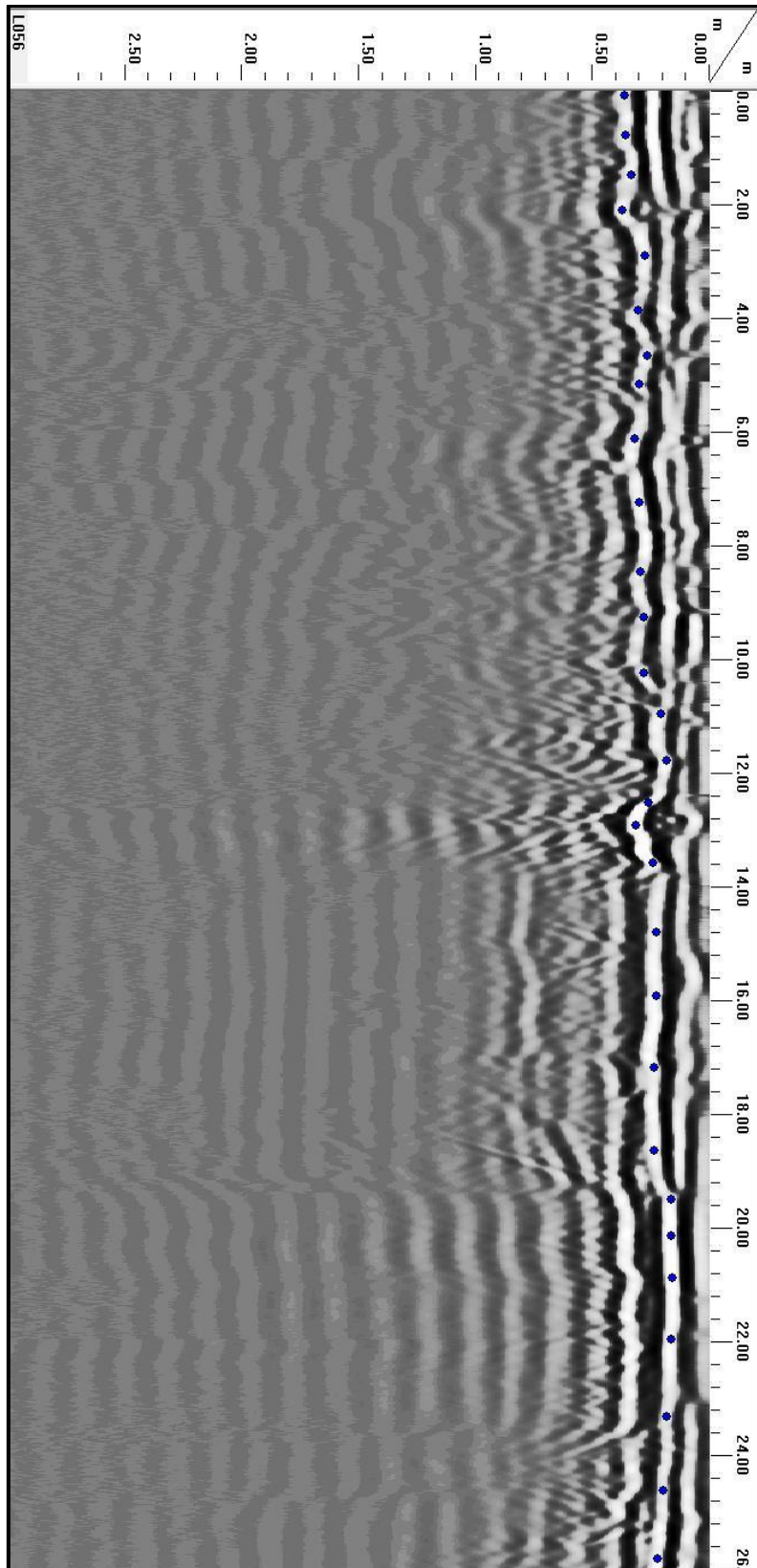


Figure 75: McGowan Hall Anomaly 2 displayed at 0.14 meters.

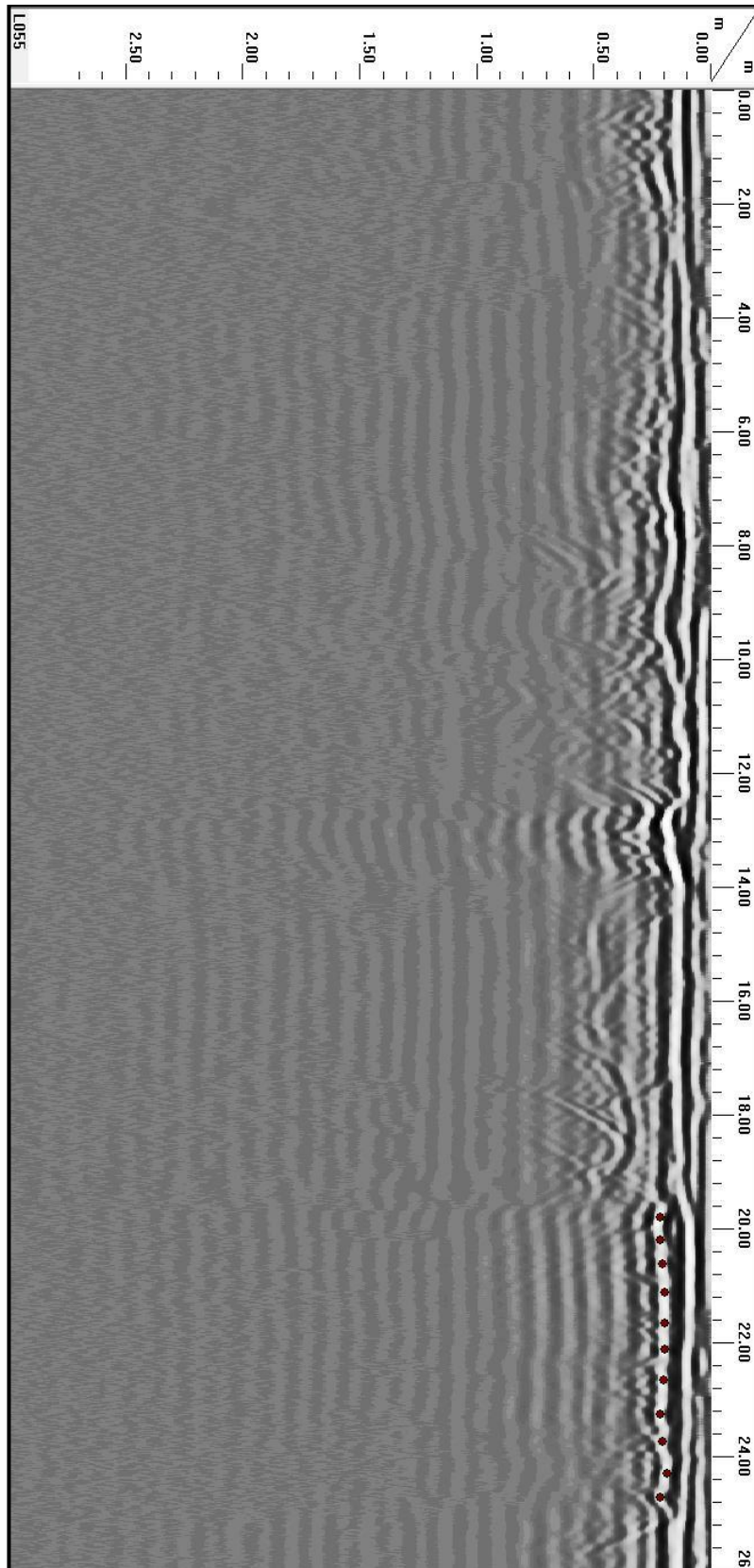


Figure 76: McGowan Hall Anomaly 3.

## Appendix D: Orphans' Home Time Slices and Radargrams

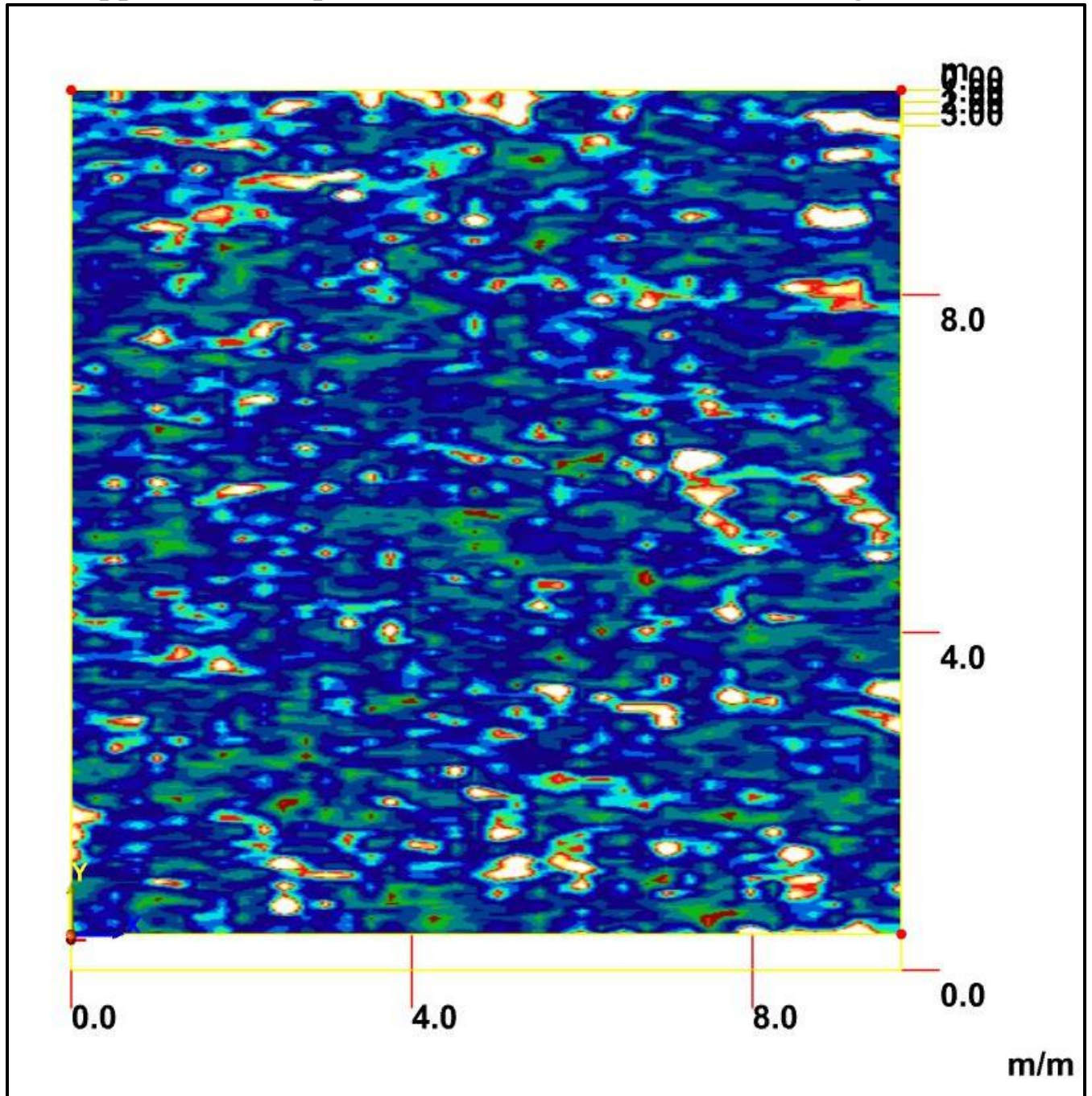


Figure 77: Orphans' Home Ground Surface.



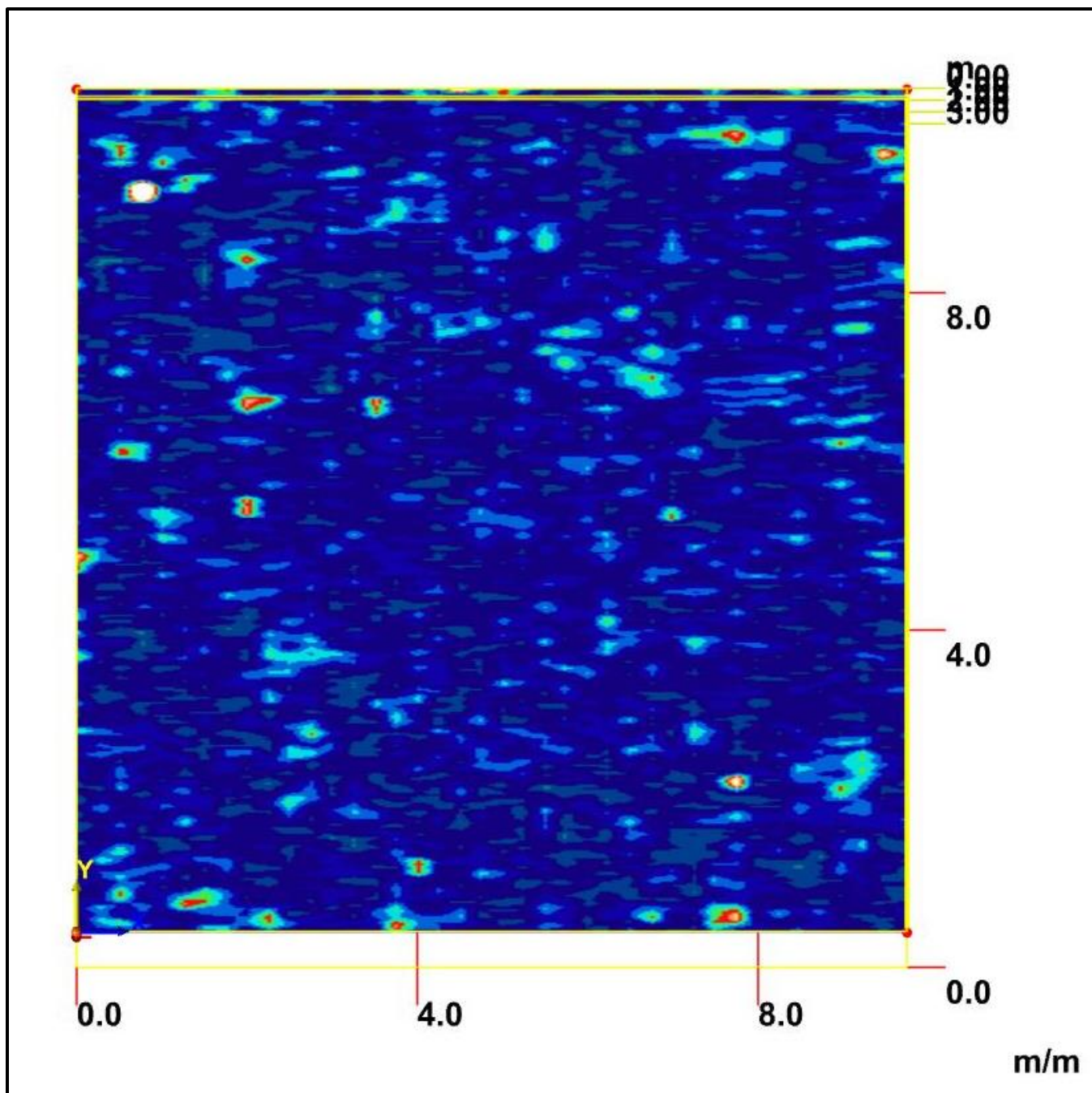


Figure 78: Orphans' Home 10 CM below Ground Surface.

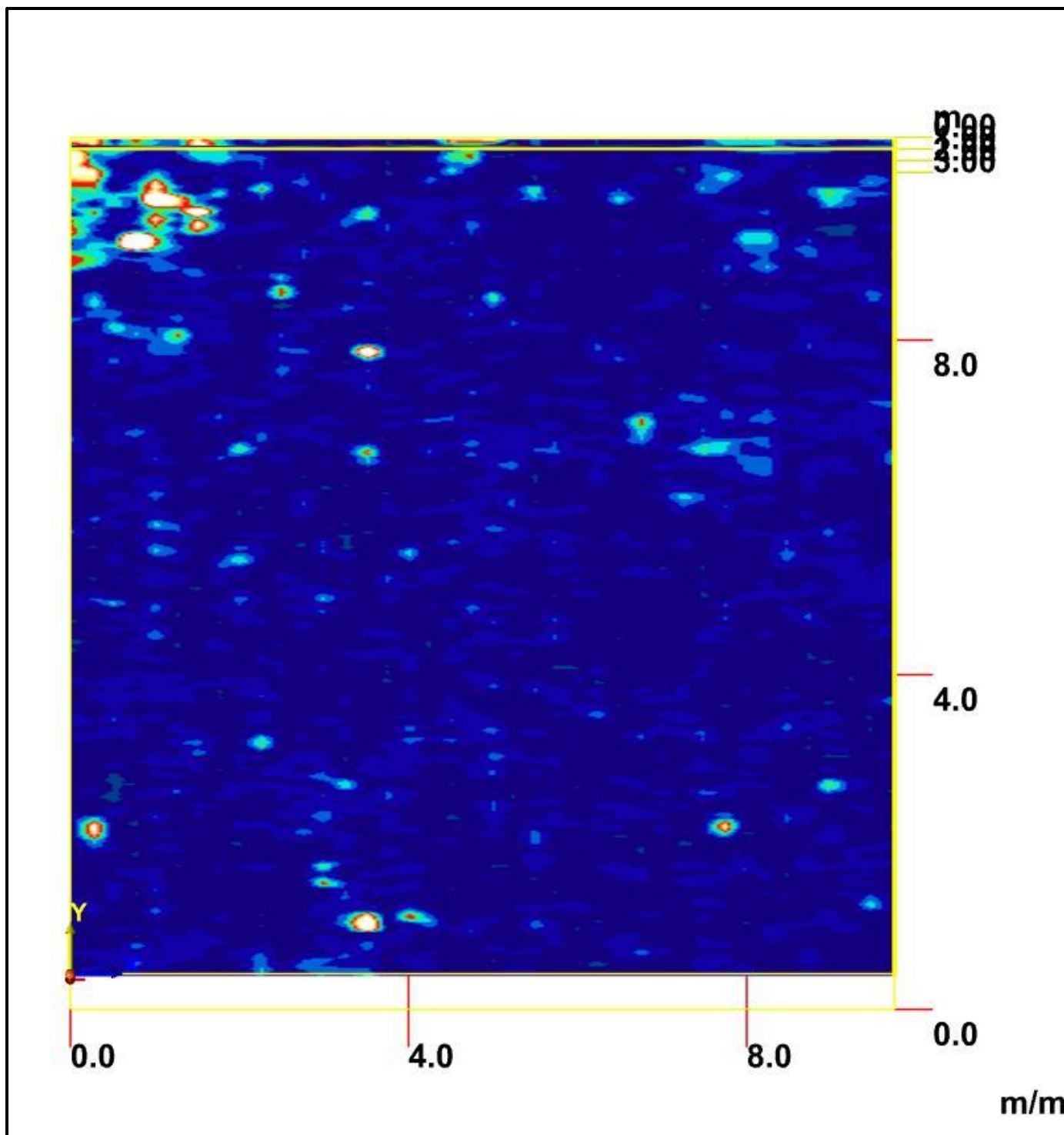


Figure 79: Orphans' Home 20 CM below Ground Surface.

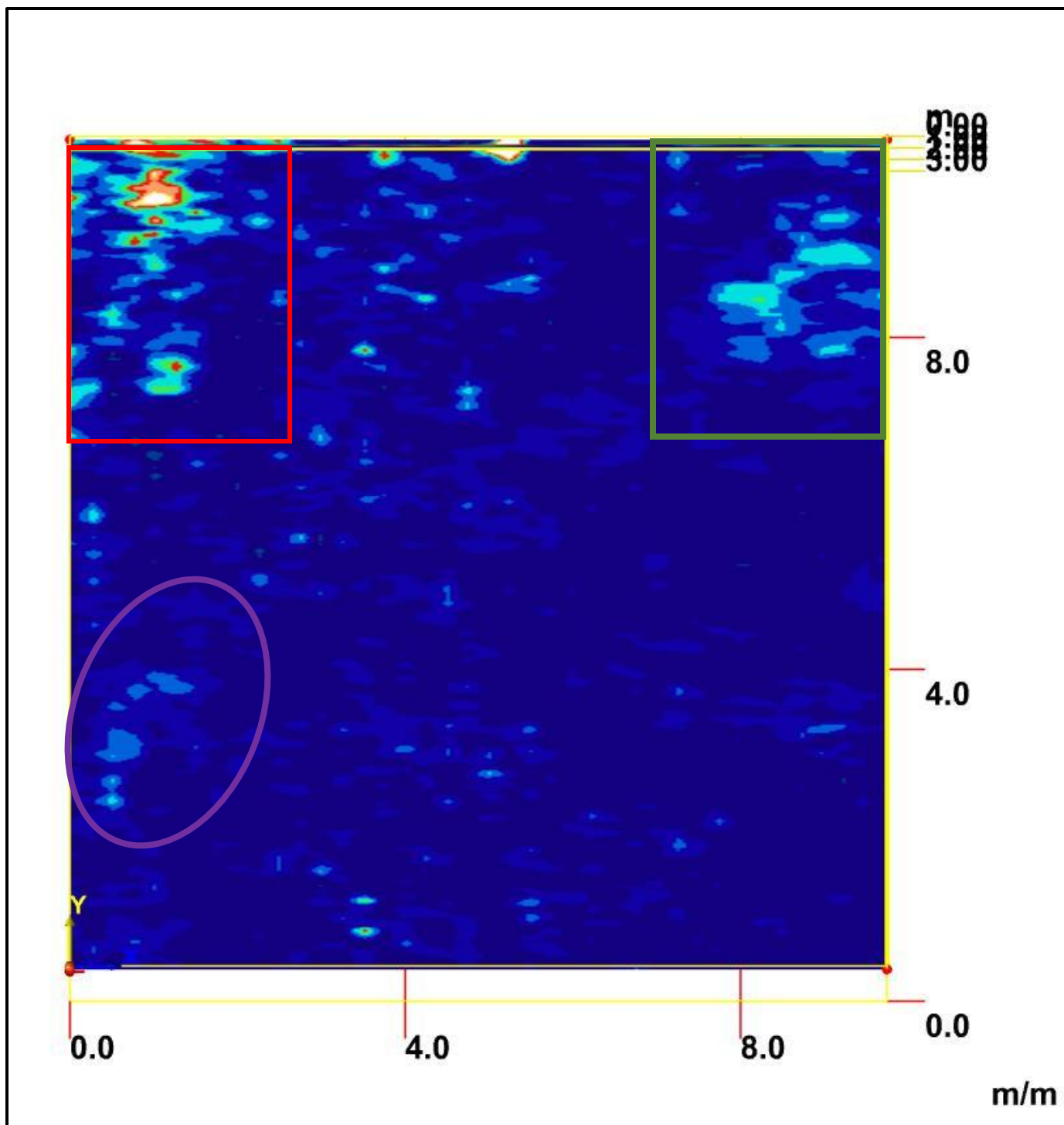


Figure 80: Orphans' Home 30 CM with Anomaly 1 (red), Anomaly 2 (purple), and Anomaly 3 (green).

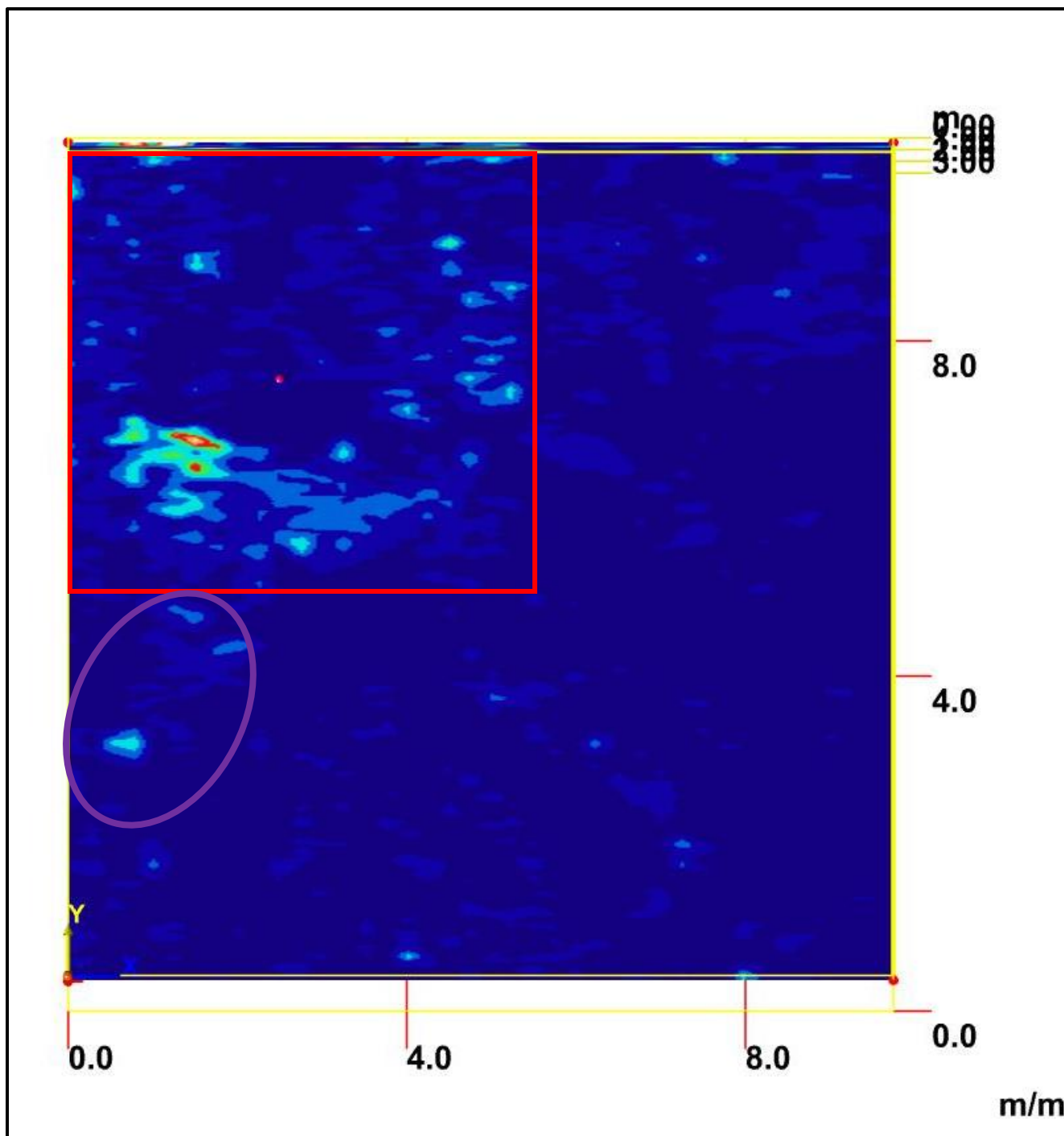


Figure 81: Orphans' Home 40 CM with Anomaly 1 (red) and Anomaly 2 (purple).



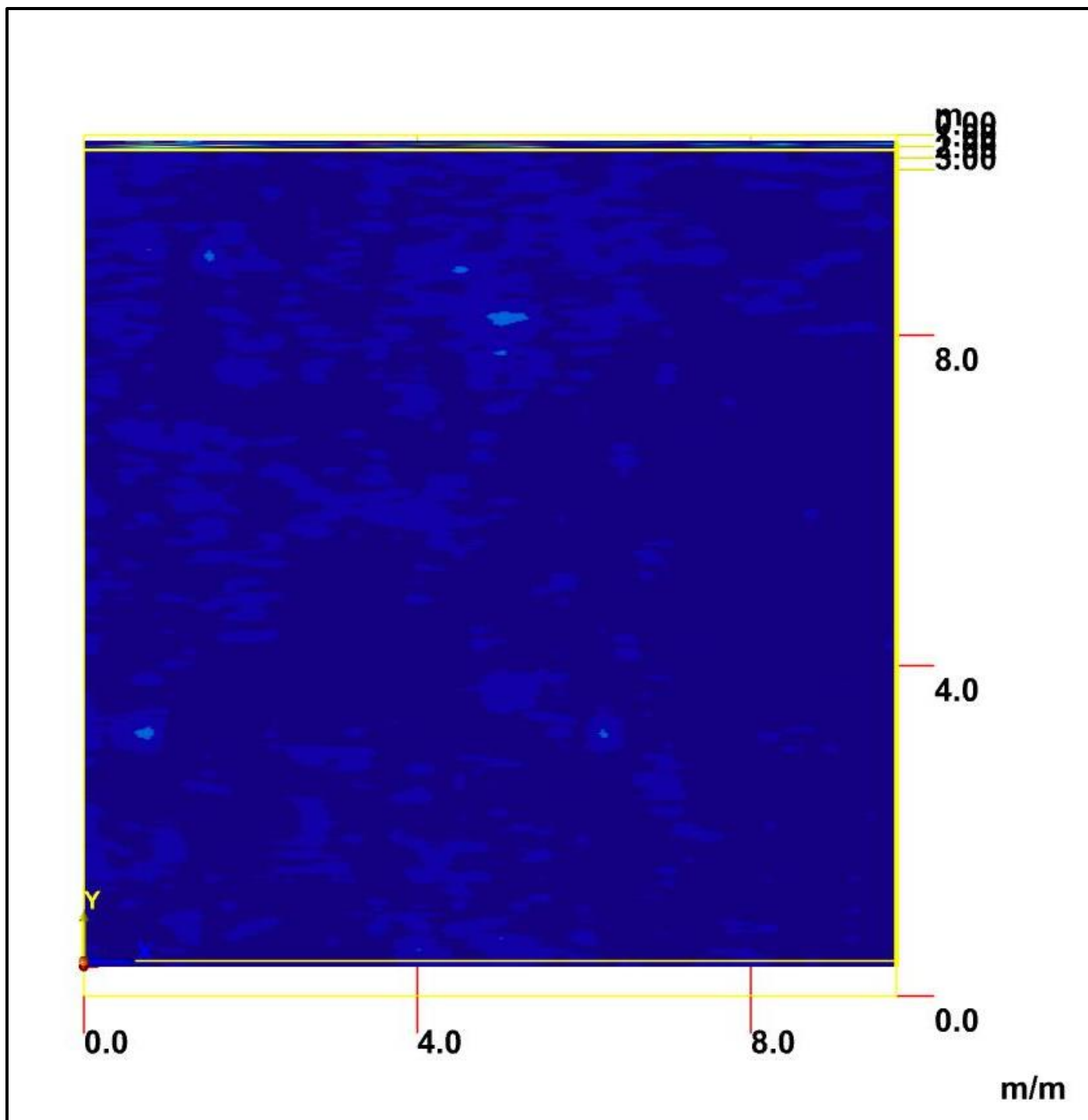


Figure 82: Orphans' Home 50 CM below Ground Surface.



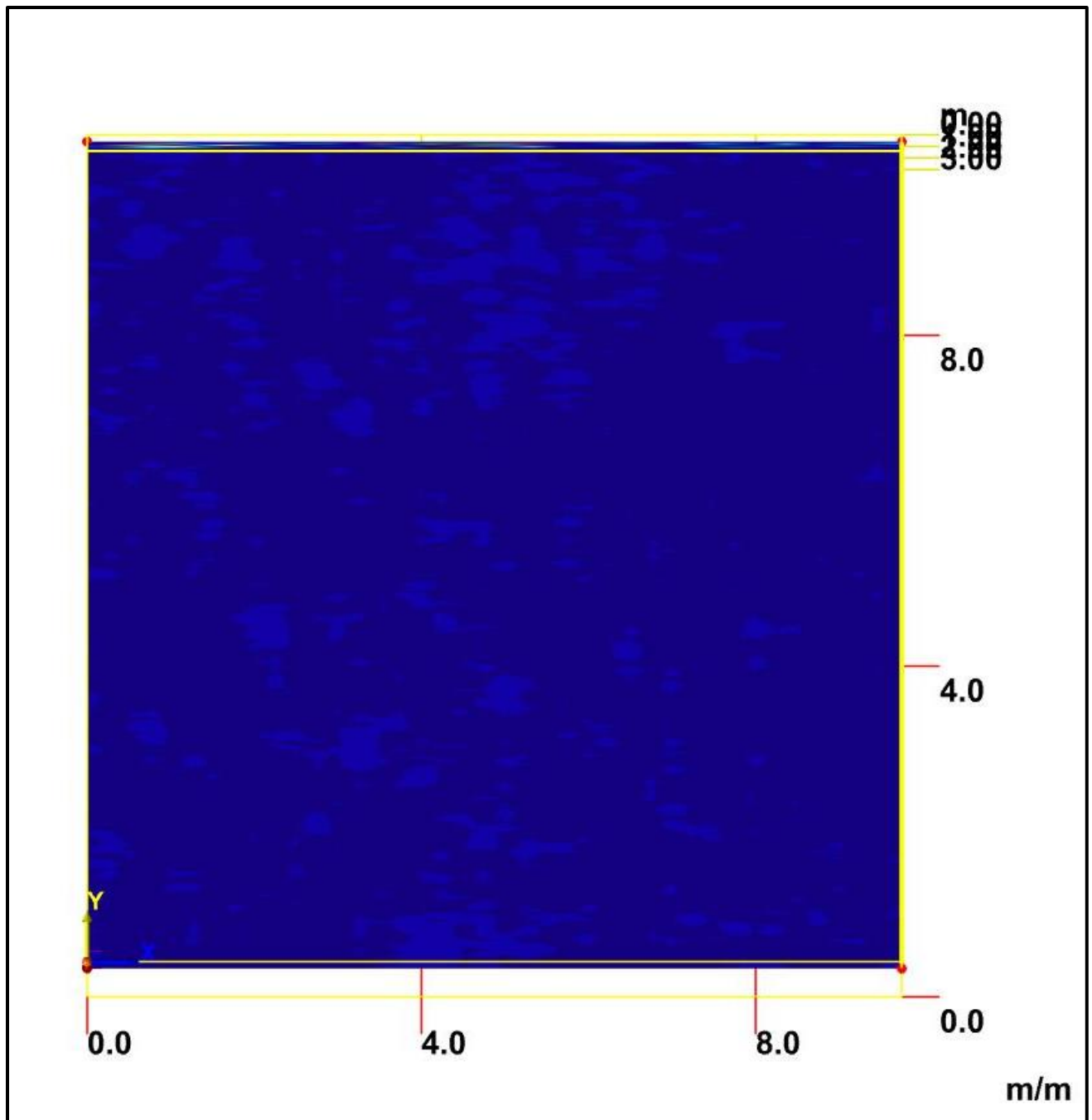


Figure 83: Orphans' Home 60 CM below Ground Surface.

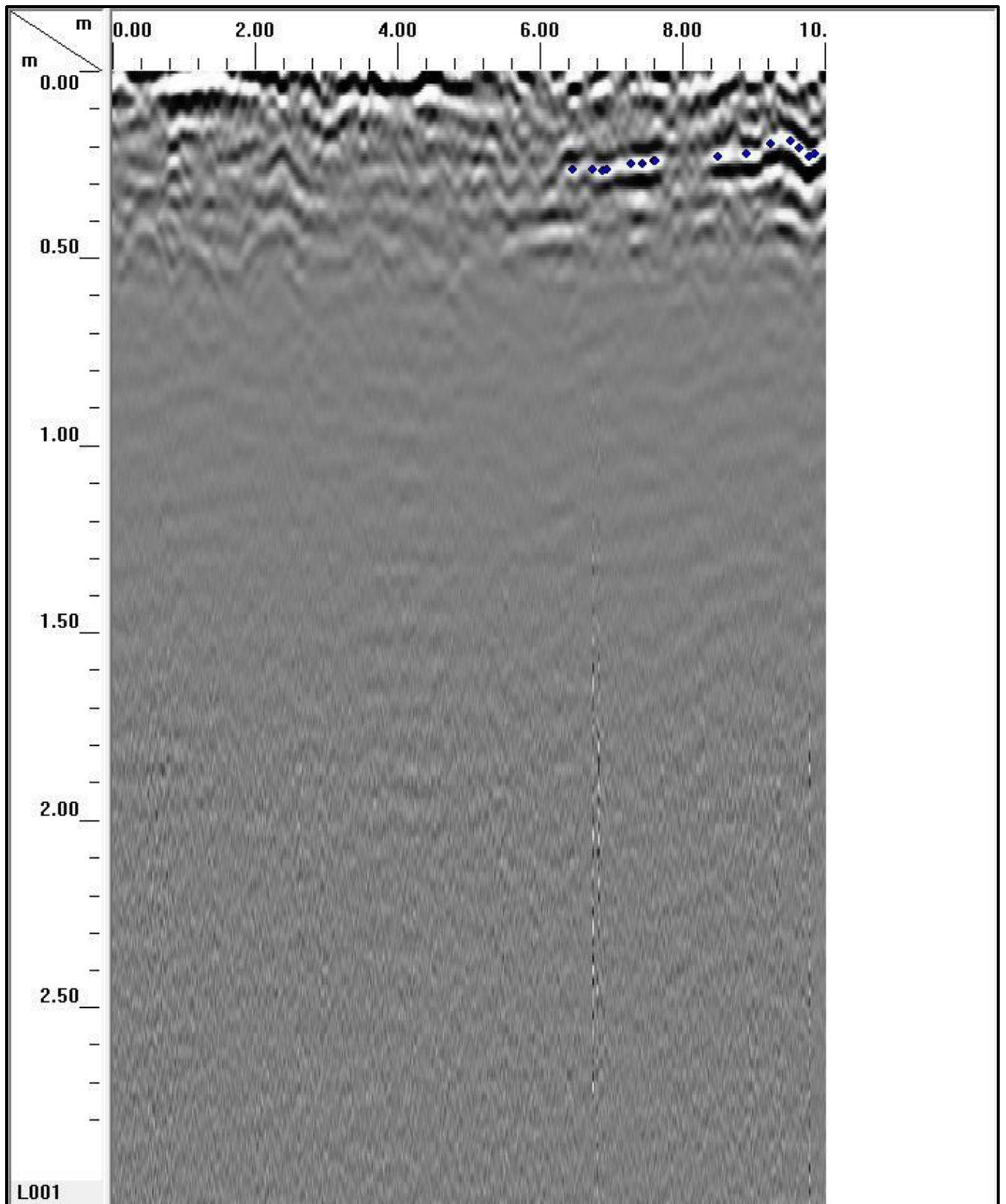


Figure 84: Orphans' Home Anomaly 1.

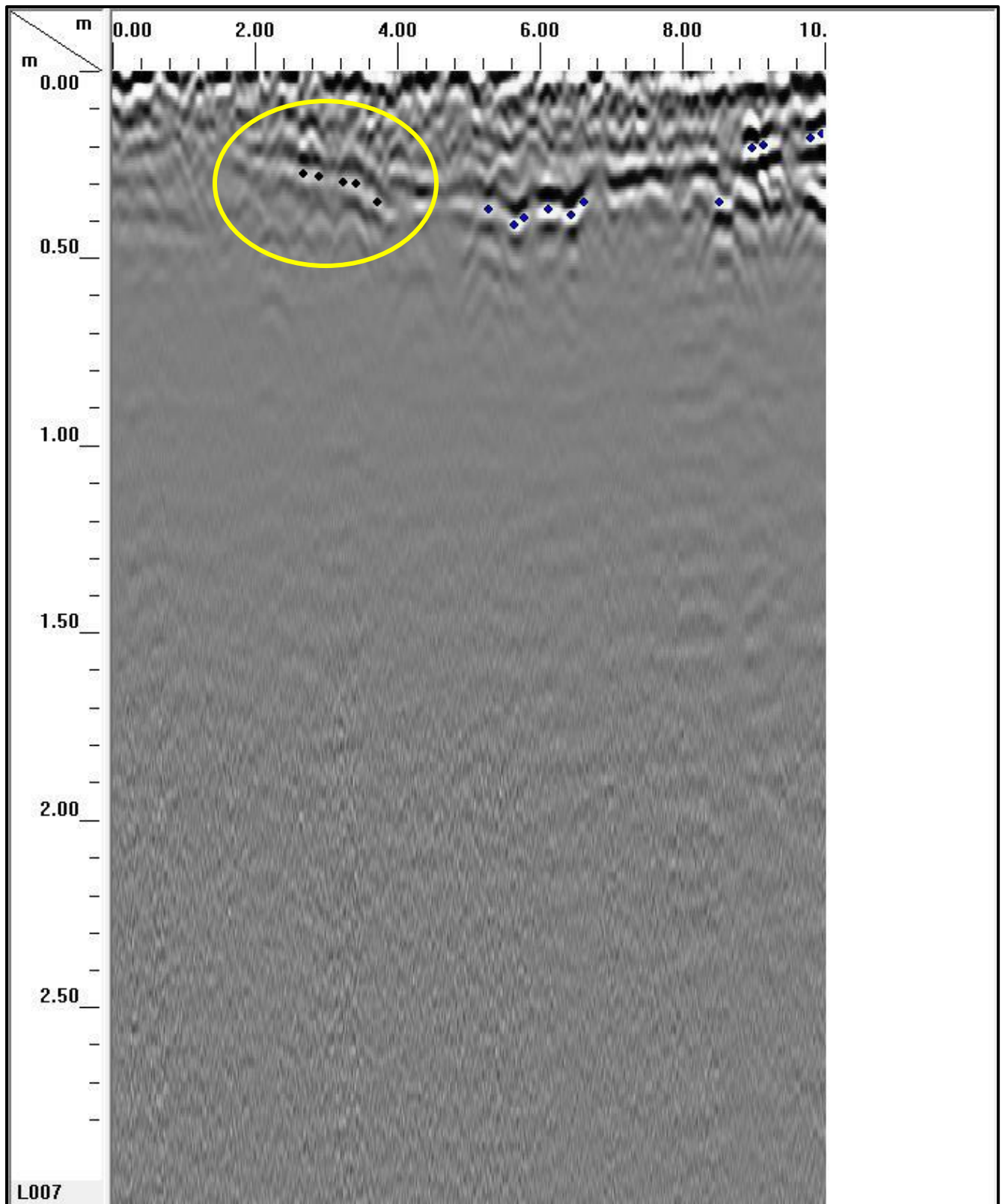


Figure 85: Orphans' Home Anomaly 1 and Anomaly 2 (circled).

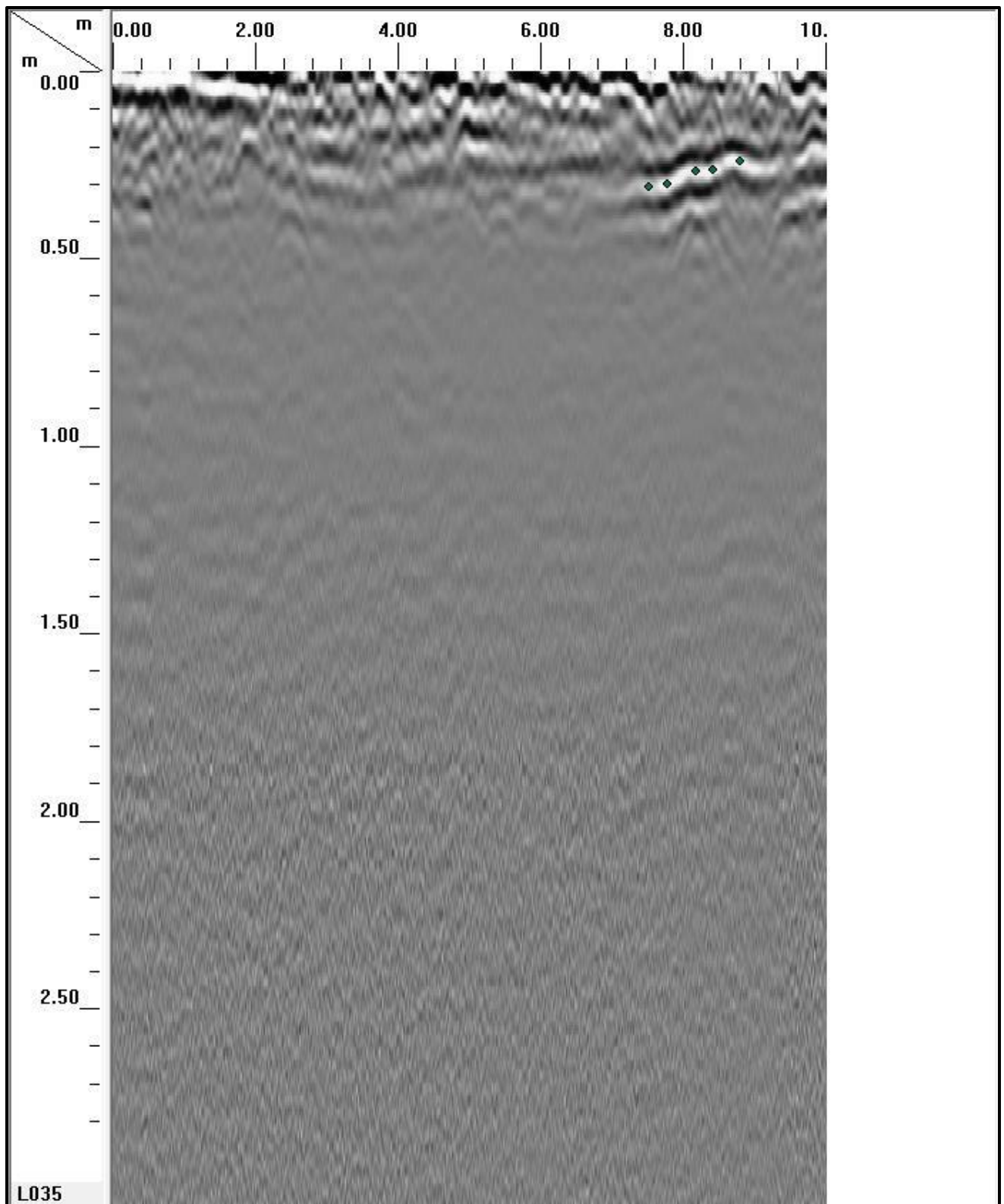


Figure 86: Orphans' Home Anomaly 3.



## Appendix E: Eaton House Time Slices and Radargrams

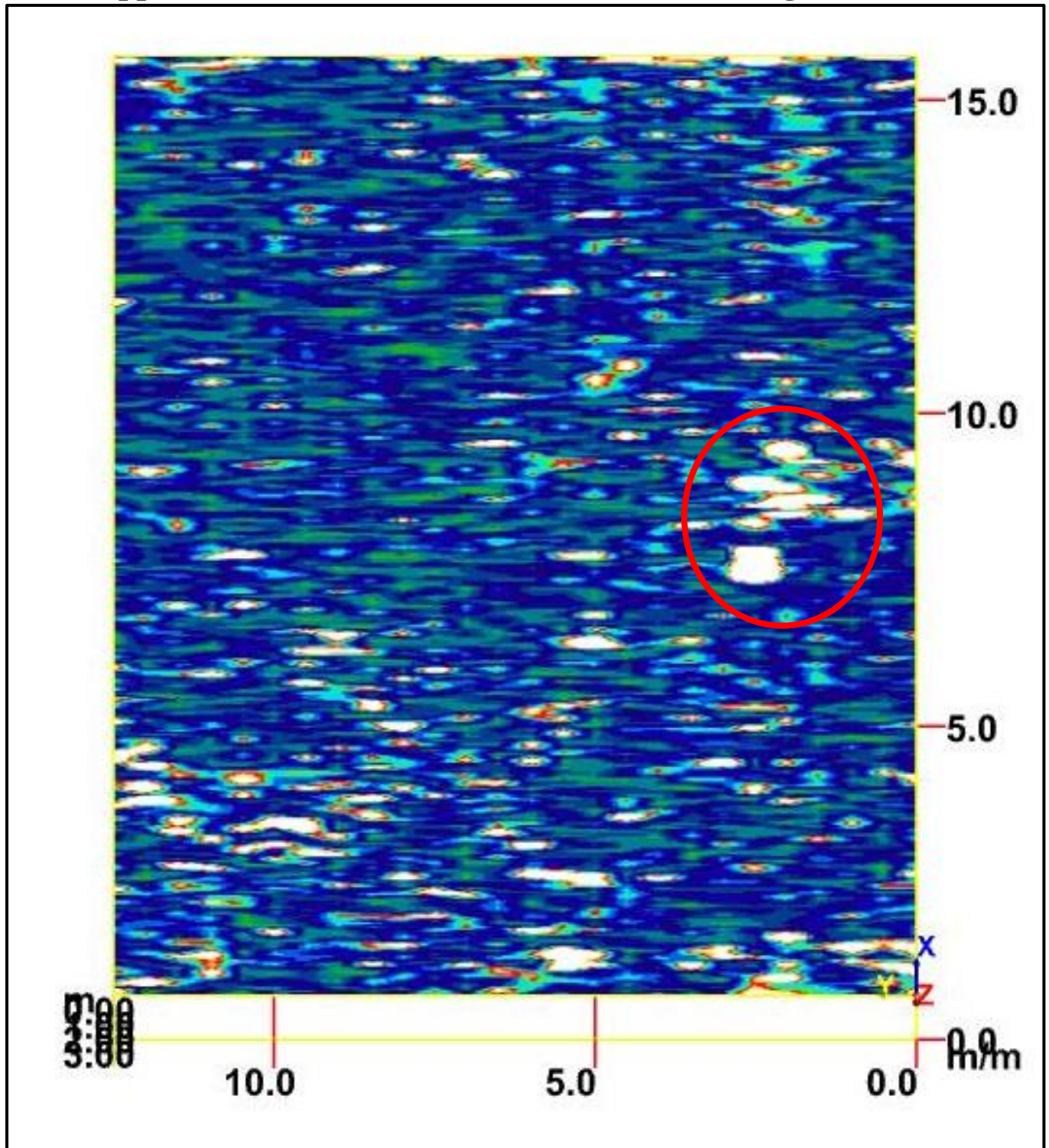


Figure 87 Eaton House Ground Surface with Anomaly 2 (red).

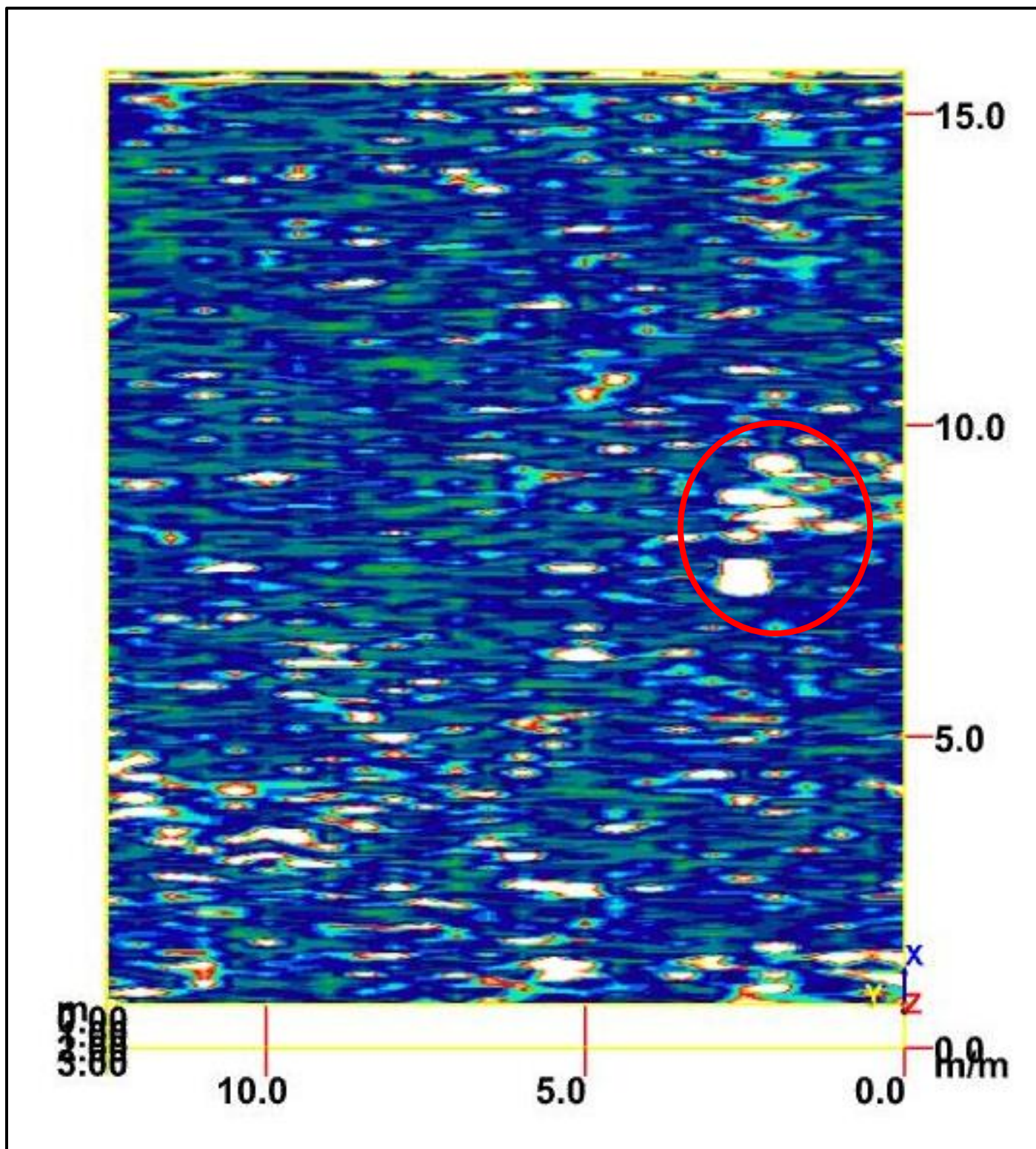


Figure 88: Eaton House 10 CM with Anomaly 2 (red).



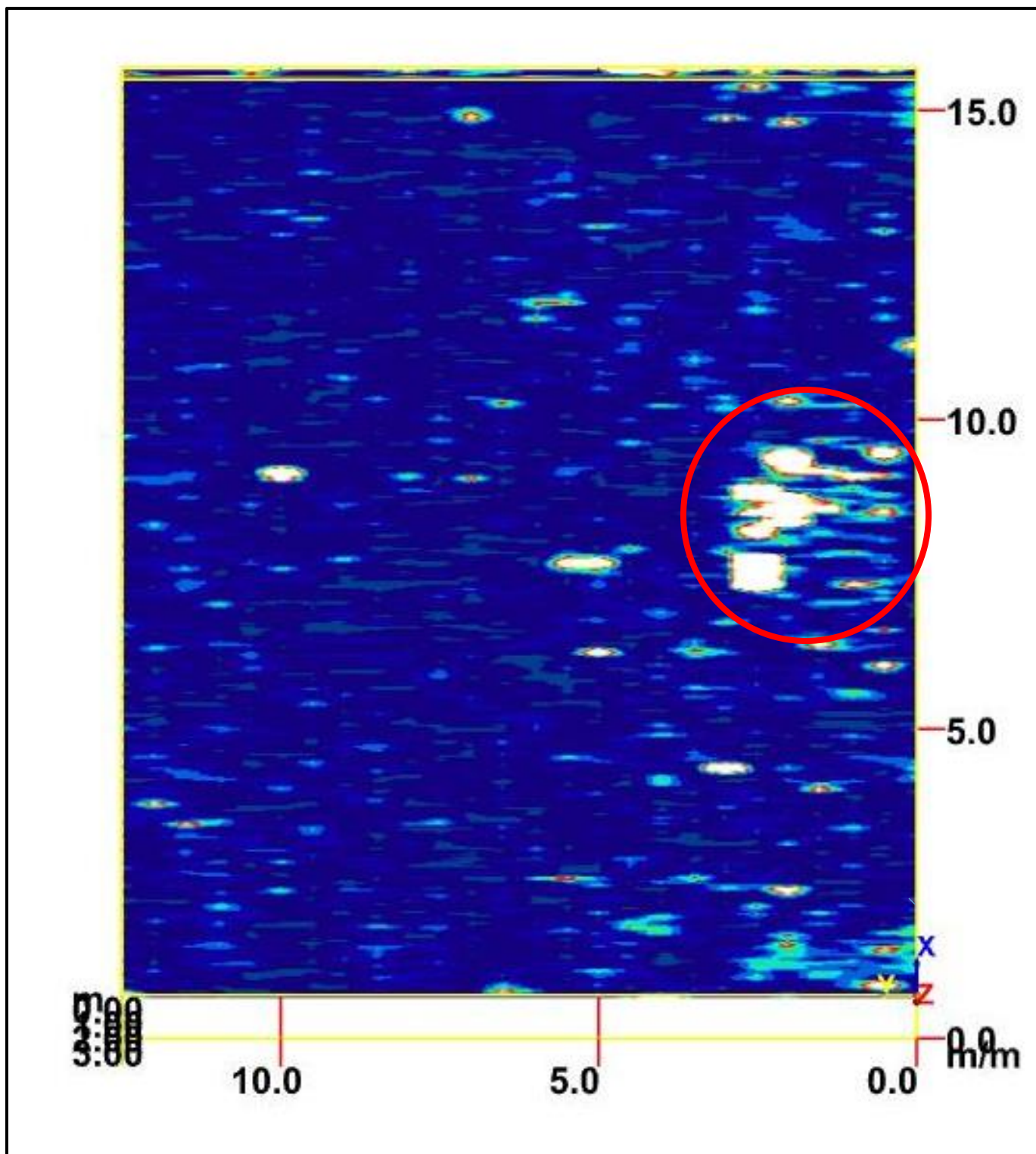


Figure 89: Easton House 20 CM with Anomaly 2 (red).

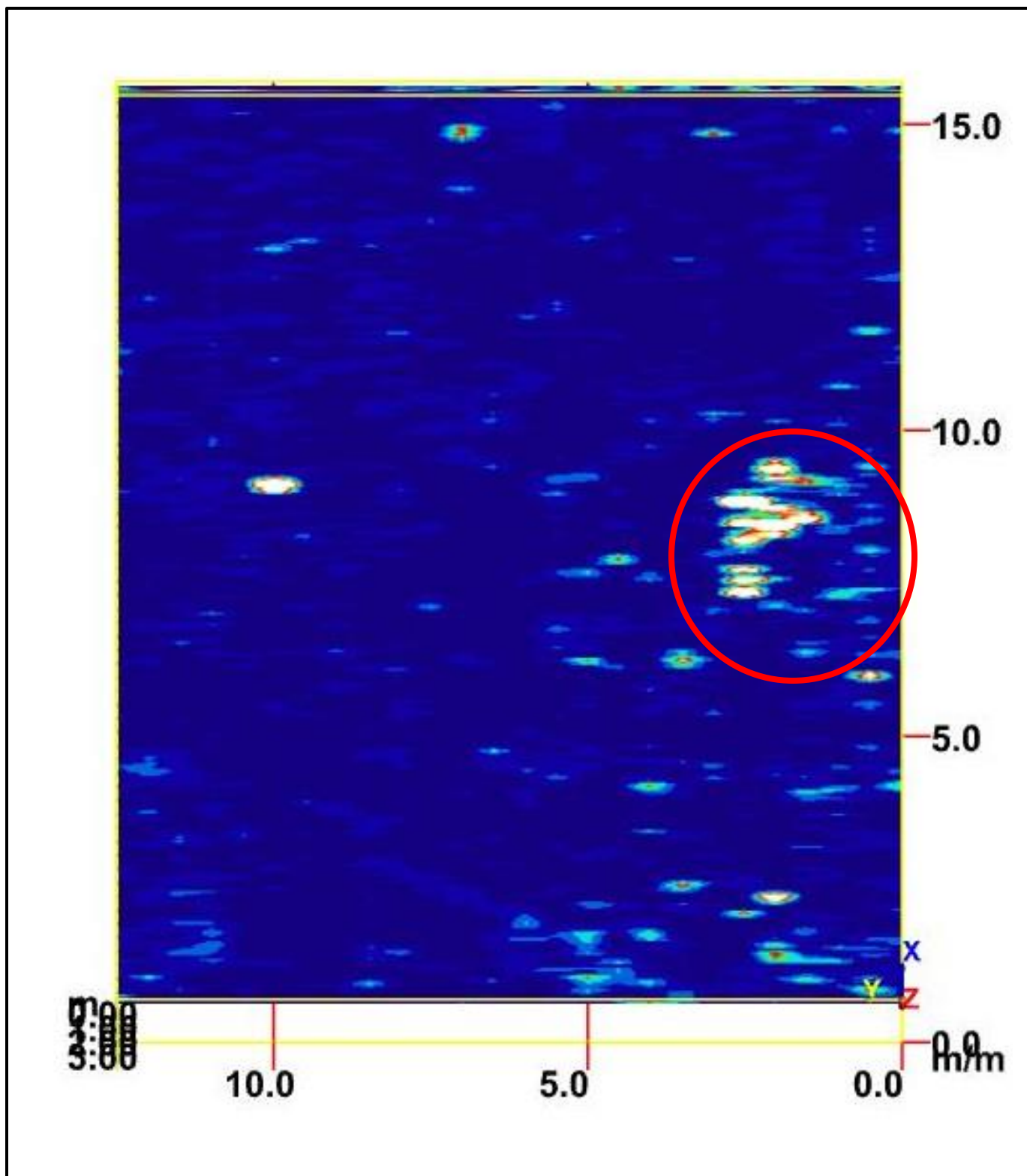


Figure 90: Eaton House 30 CM with Anomaly 2 (red).



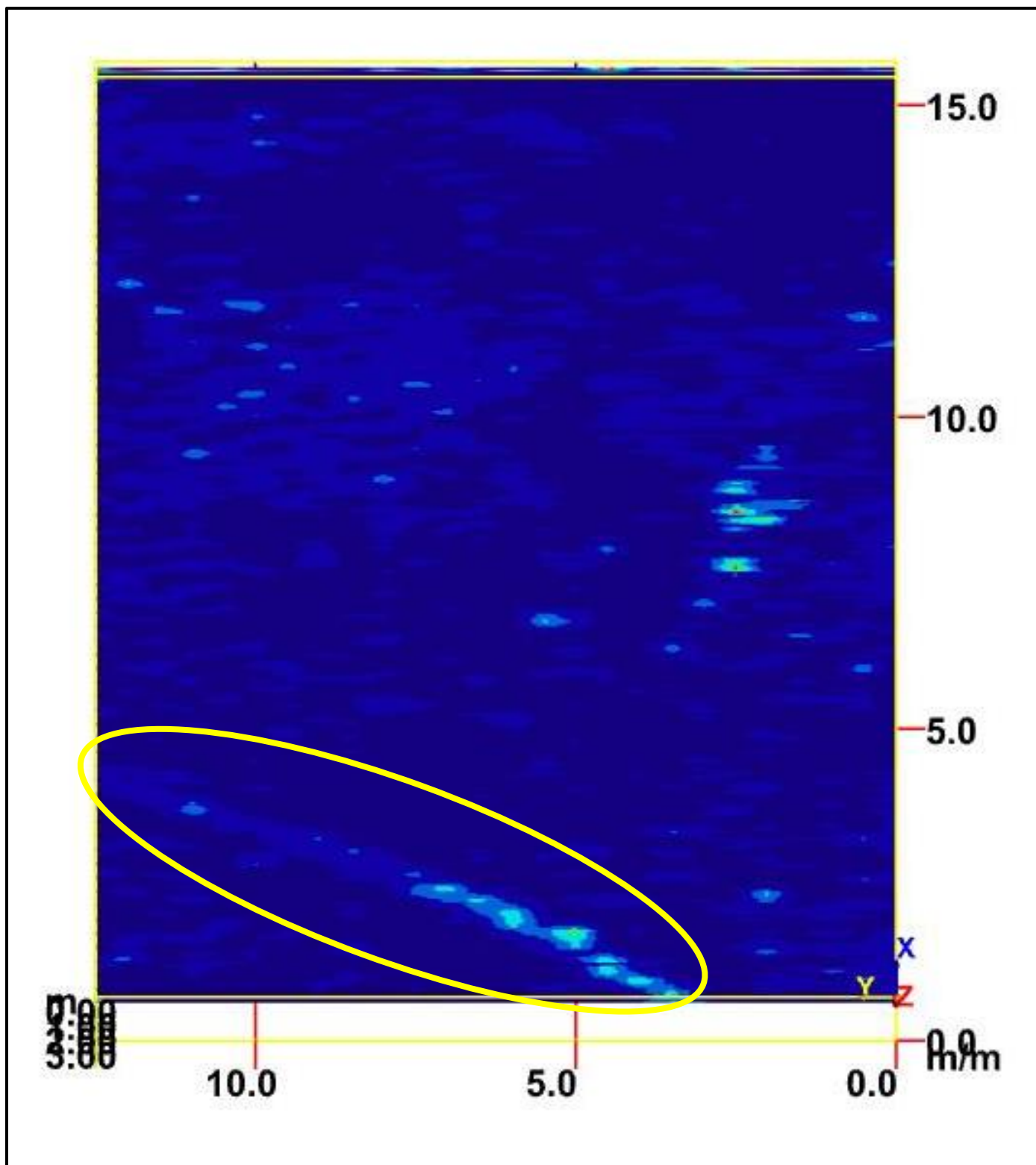


Figure 91: Easton House 40 CM with Anomaly 1 (yellow).

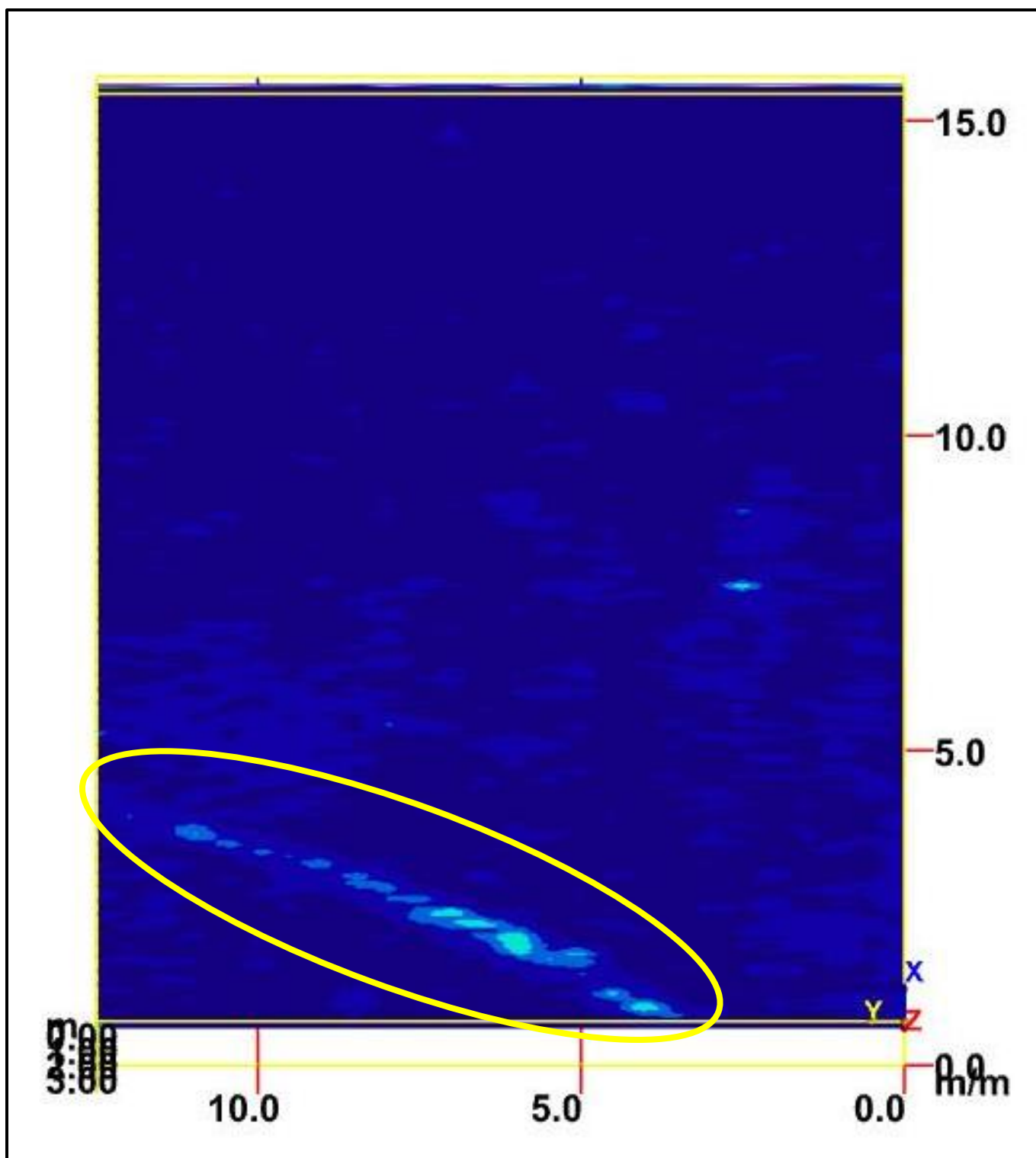


Figure 92: Eaton House 50 CM with Anomaly 1 (yellow).

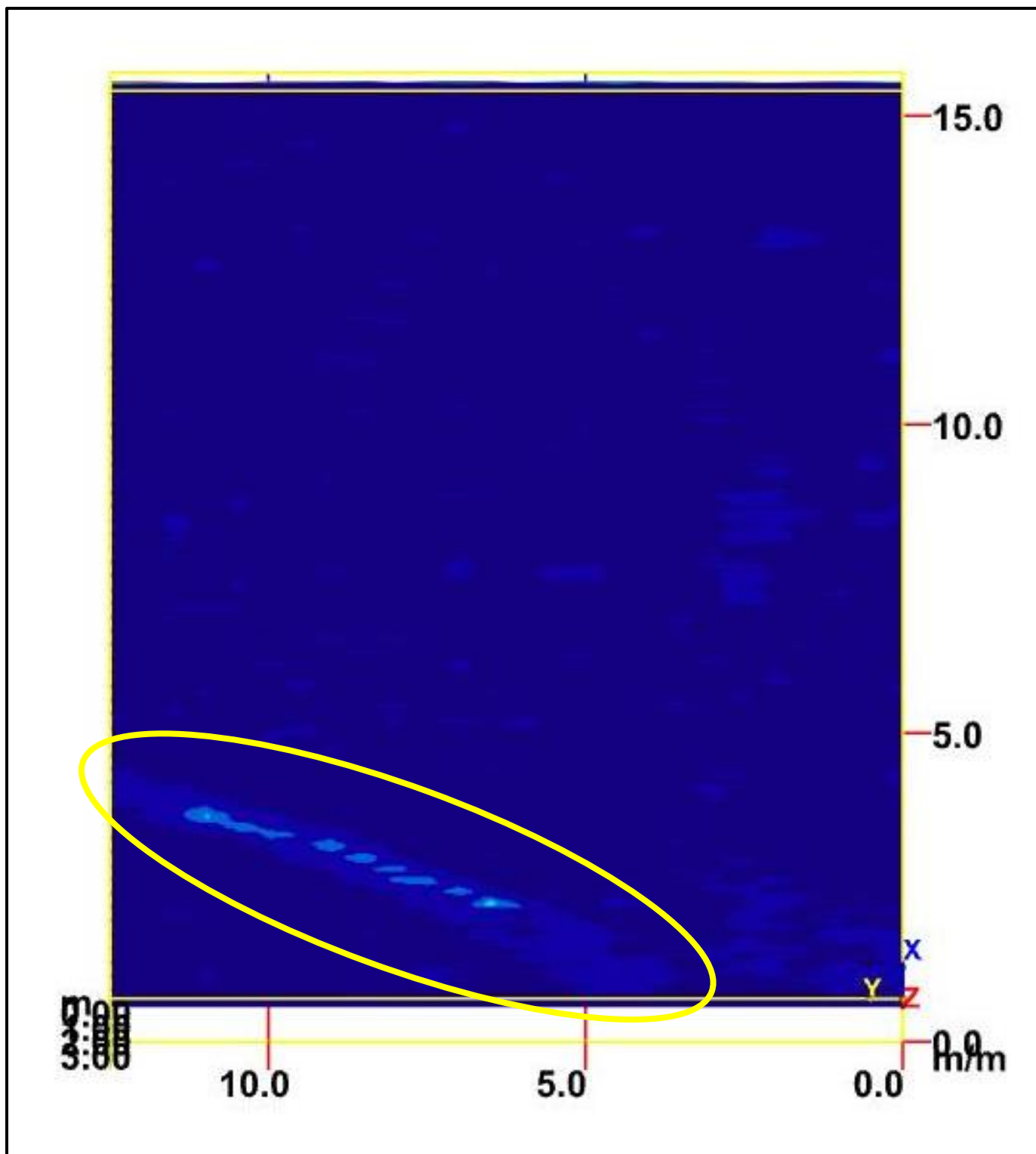


Figure 93: Eaton House with Anomaly 1 (yellow).

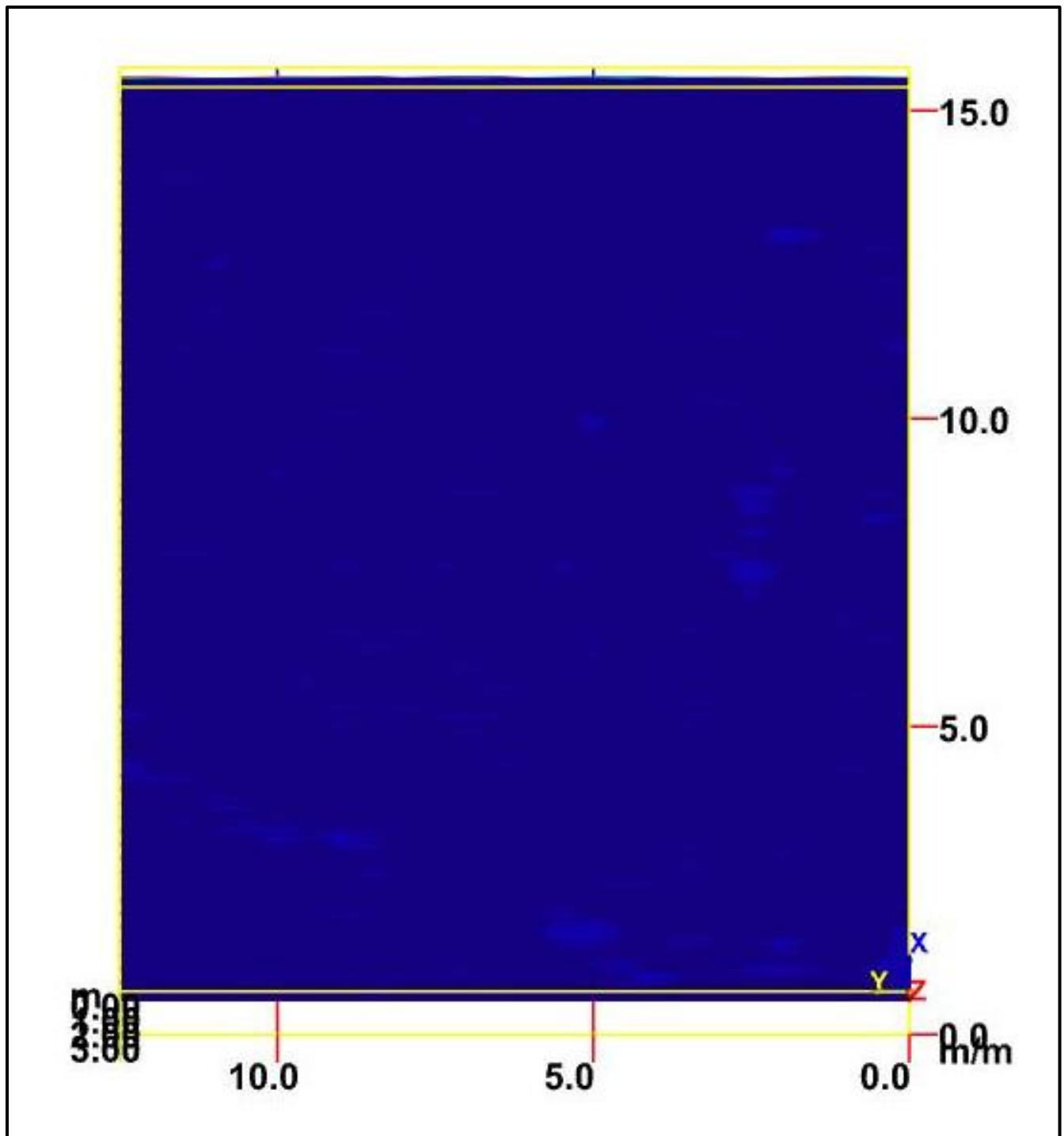


Figure 94: Eaton House 70 CM below Ground Surface.

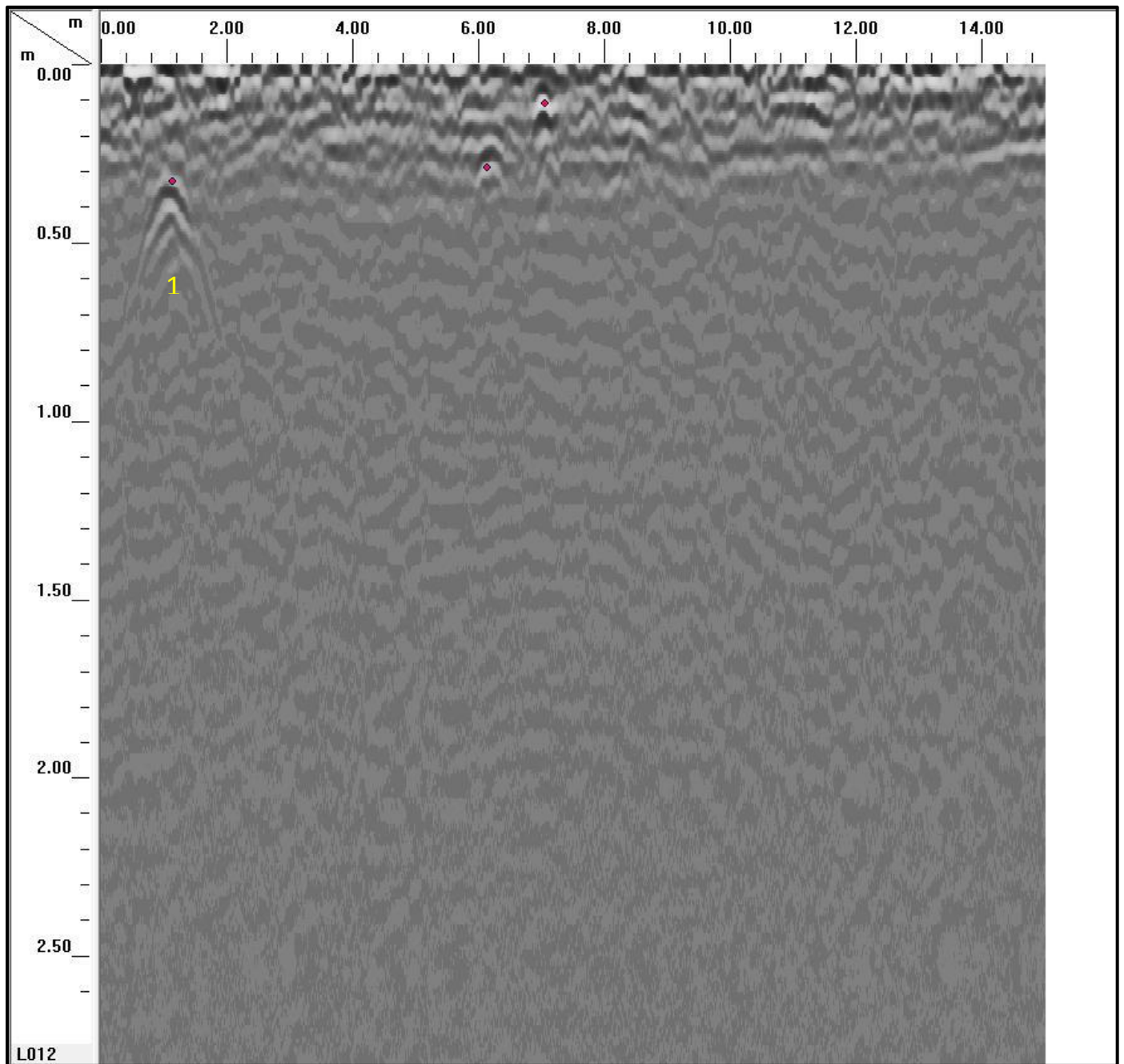


Figure 95: Eaton House Anomaly 1 (far left) and smaller hyperbolas.

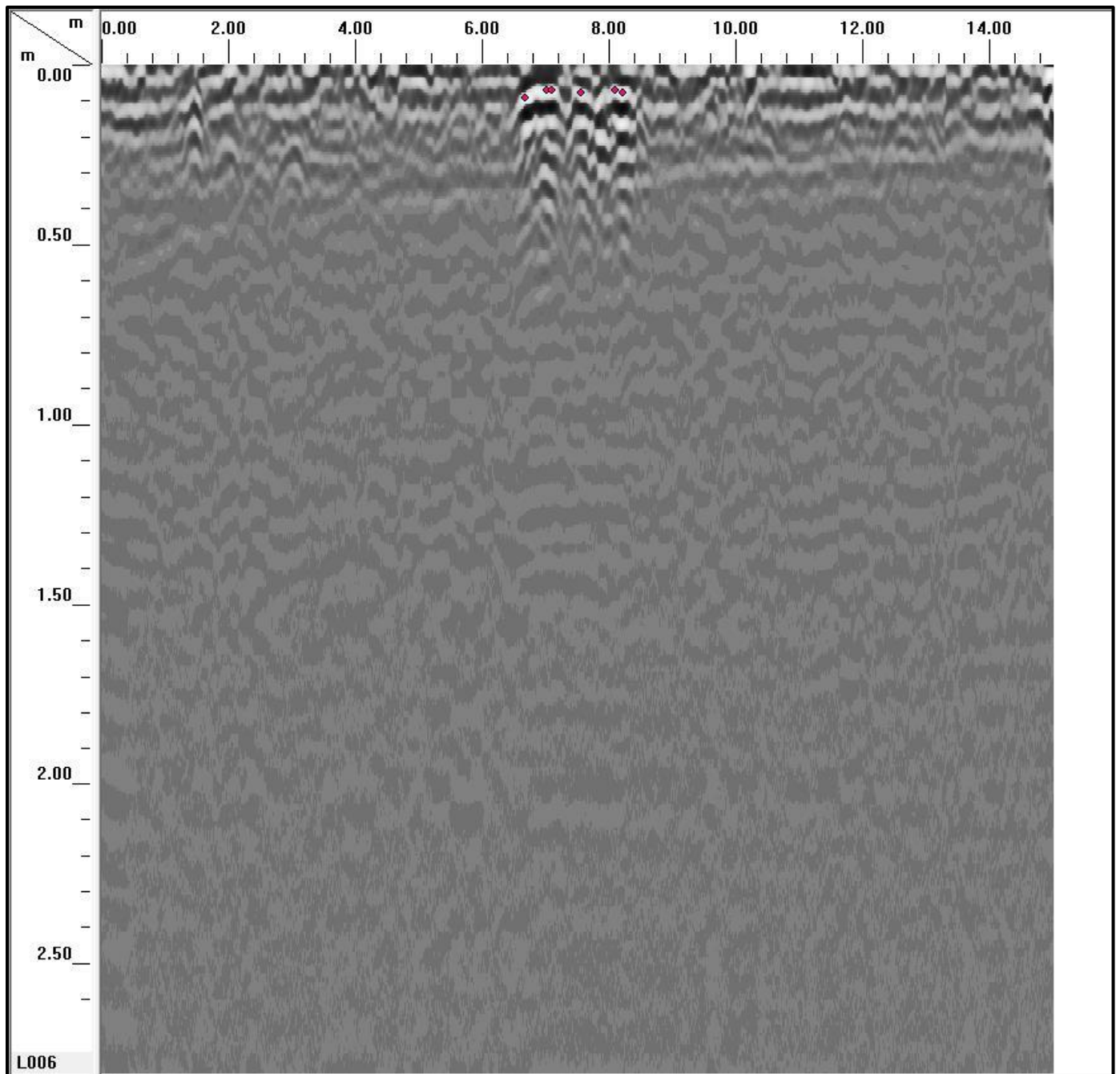


Figure 96: Eaton House Anomaly 2.



## Appendix F: Survey Grid Maps

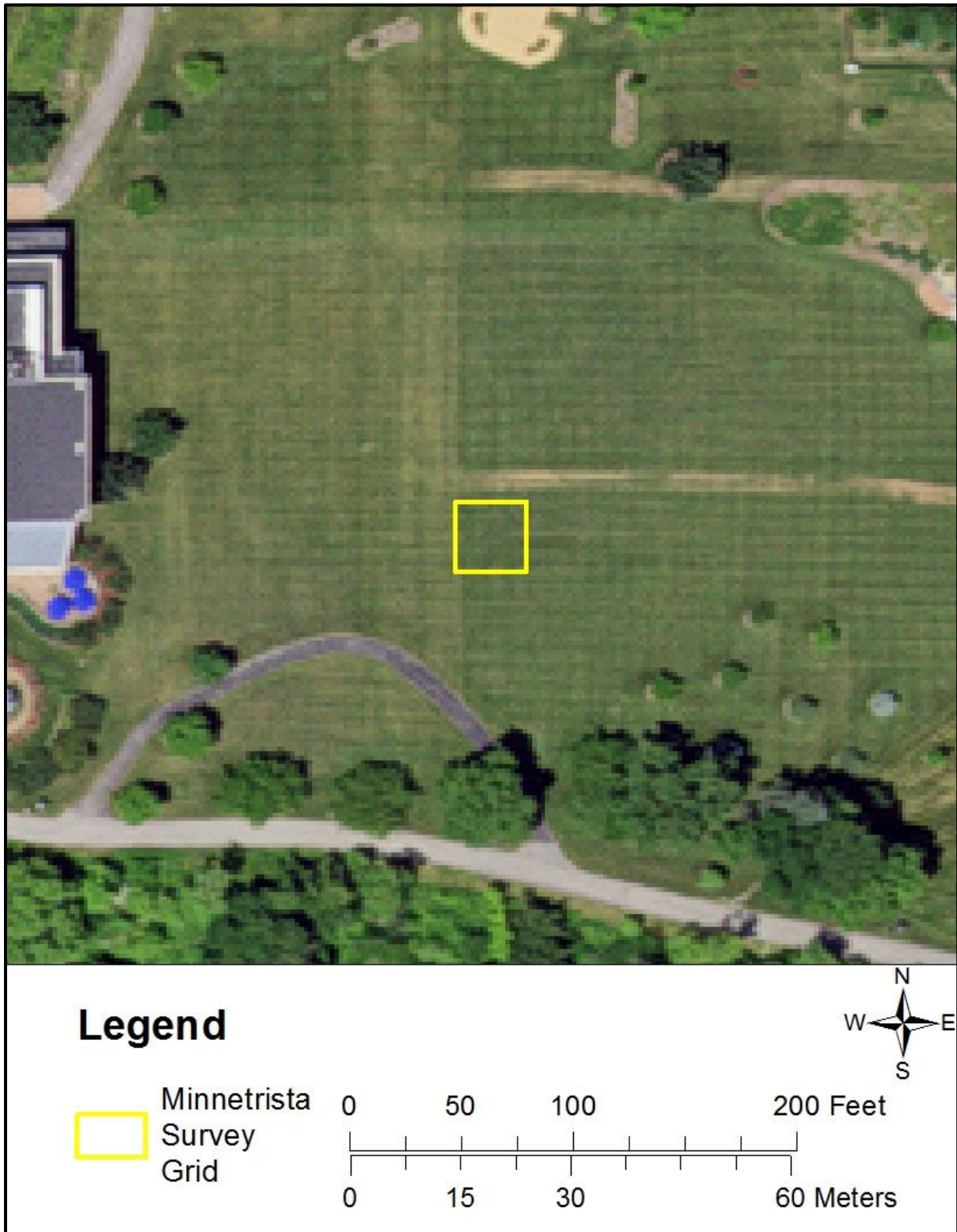


Figure 97: Minnetrista Orphans' Home Survey Grid (USGS 2016).

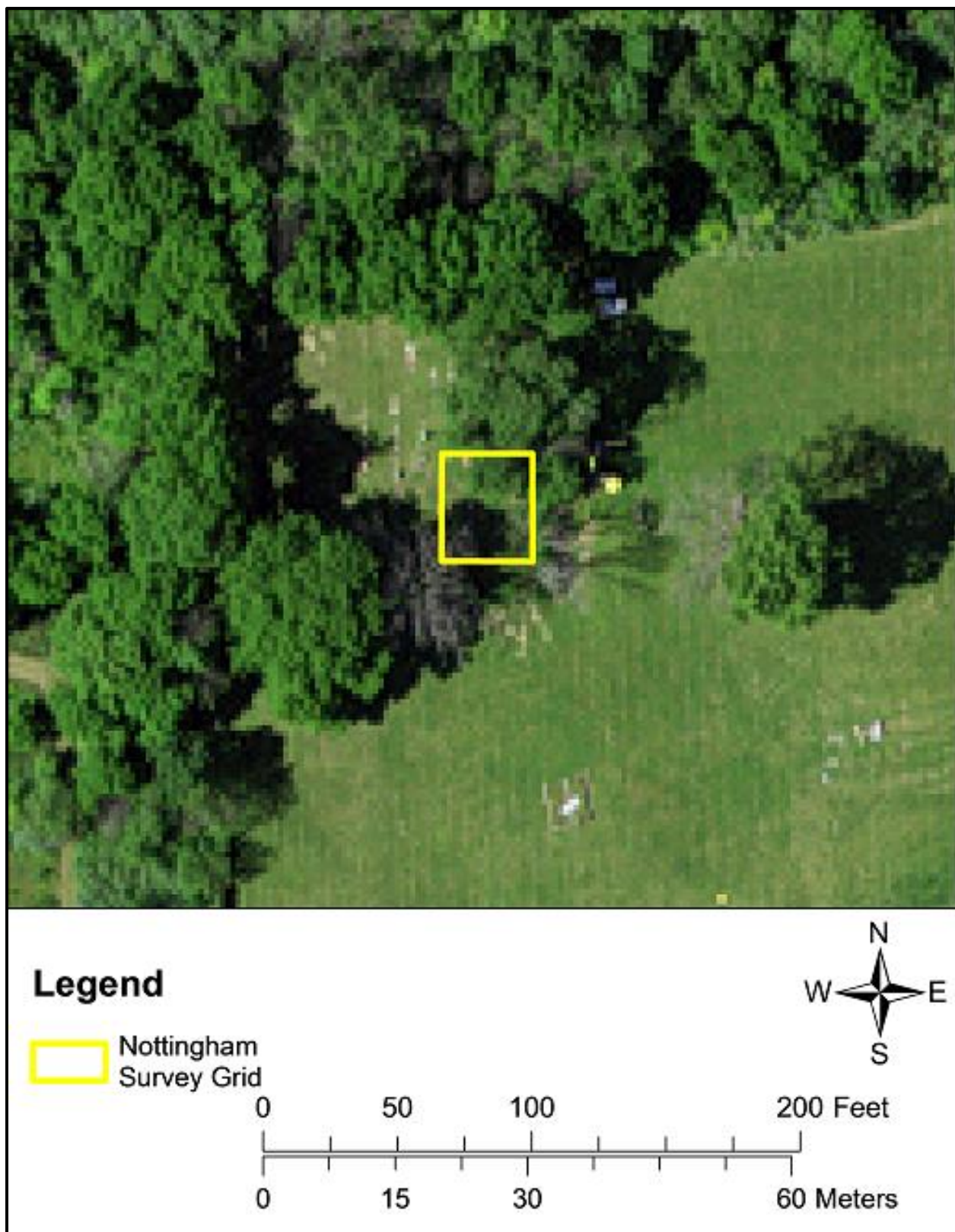


Figure 98: Nottingham Cemetery Survey Grid (USGS 2016).





Figure 99: Eaton House Survey Grid (USGS 2016).

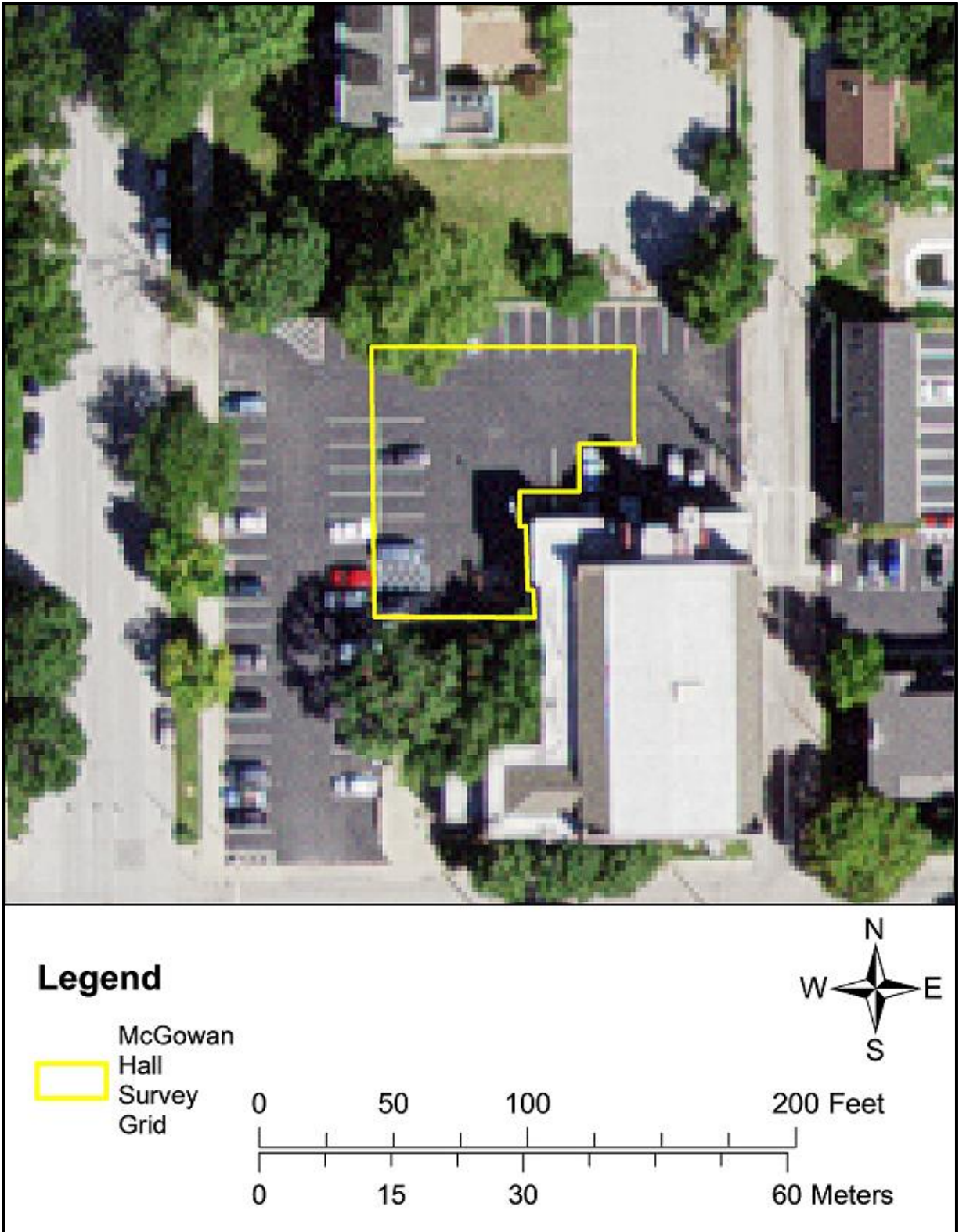


Figure 100: Knights of Columbus McGowan Hall Survey Grid (USGS 2016).



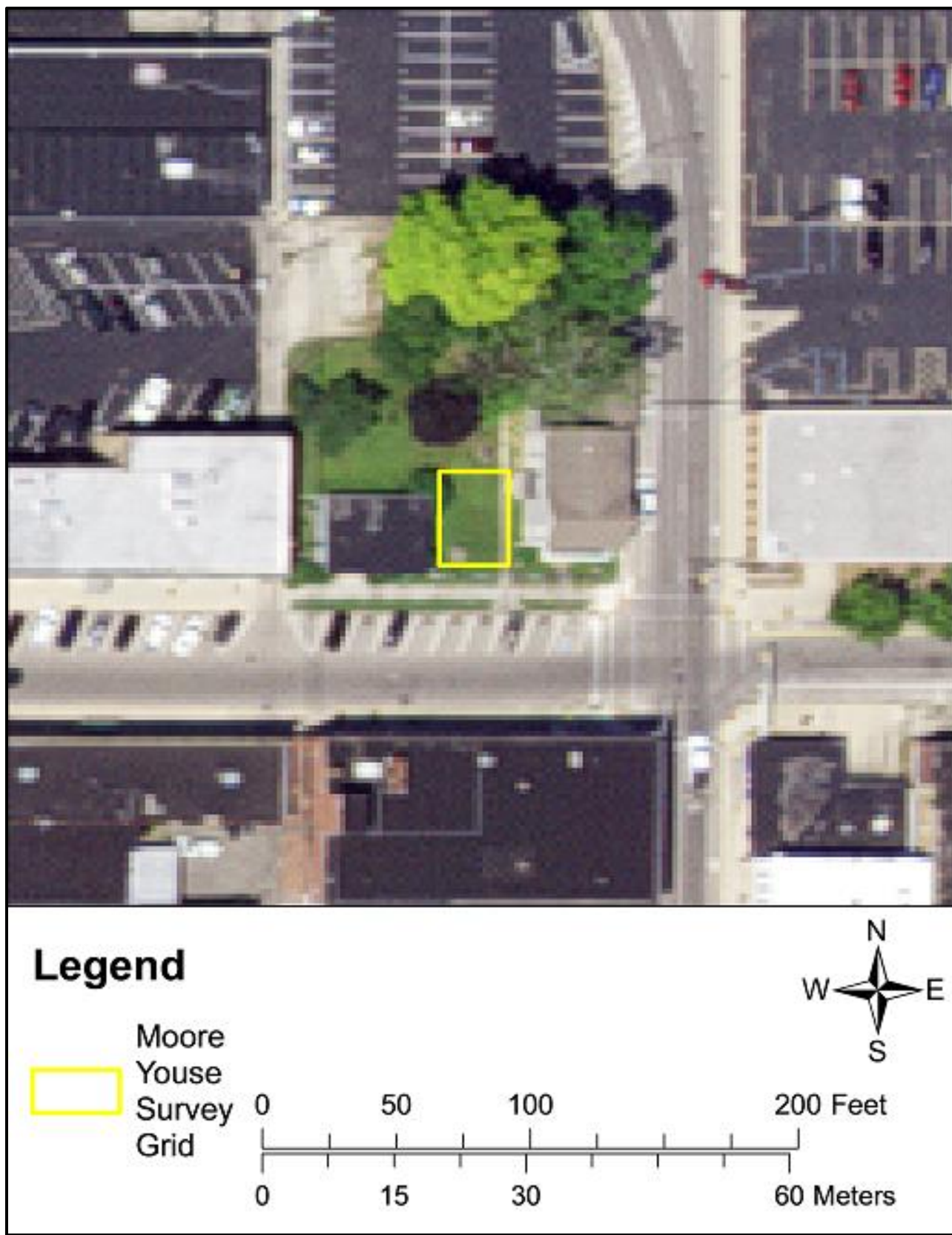


Figure 101: Moore Youse House Survey Grid (USGS 2016).

## Appendix G: Forms



Dear Sir/Ma'am,

Thank you for your interest in the 2016 ground penetrating radar (GPR) catalog project that I am conducting. My name is Amanda Balough and I am a historical archaeology master's student with the Department of Anthropology at Ball State University. During fall 2016 I will be collecting field data for my thesis. For my thesis, I will be creating a catalog of ground penetrating radar survey results from a sample of historic and prehistoric sites. You are being contacted because you supervise/own a site of interest.

My thesis project requires survey with GPR equipment, which resembles a push lawn mower. The radar unit is pushed across the ground along an established site grid and gathers data along grid lines. The radar carriage can survey property with tall grass, but cannot survey in thick shrubs, wooded areas, or areas with excessive stumps or rocks. Precautions will be taken to prevent any unnecessary damage to the property and items on the property. The gathered radar data is then analyzed and interpreted in a computer program to show the below ground surface presence of archaeological features, such as building foundations, cisterns, and wells.

I would like to thank you for your interest in the project. Fall 2016 will be spent gathering site data and Spring 2017 will be spent interpreting and writing my thesis. The interpretations for the site can be made available to you if you so wish. If you having any questions or concerns, please do not hesitate to contact me.

Sincerely,

Amanda Balough  
Archaeology M.A. Student  
Ball State University  
(253)282-1023  
aebalough@bsu.edu

Property owners:

Signature: _____	Date: _____
Signature: _____	Date: _____
Signature: _____	Date: _____

Figure 102: GPR Survey Ownership Permission Form (Amanda Balough 2016).



## Appendix H: Nottingham Grave List

Table 15: Nottingham Grave List

Row	Last Name	First Name	Death Date	Years	Comments
	Smith	Hiram L.	1846		
4	Branson	Robert	1854	Aug. 20, 1802-Jan. 6, 1854	
	Gayman	Daniel	1854		
2	Van Buskirk	Daniel	1856	May 14, 1865	Aged: 68y
	Smith	John C.	1856		
	Conner	Nanyce	1856		
	Van Buskirk	Issac	1856		
	Branson	Elizabeth	1857	Feb. 26, 1857	Aged: 61y, 1m, 24d
	Jetmore	Polly	1859		
	justice	Moses, W.	1860		
	Conner	Orpha	1860		
	Smith	Edward P.	1862		
	Jetmore	John I.	1863		
	Falkenroth	George	1863		
	Justis	Florence A.	1864		
	Sears	Martha Jane	1864		
	Sears	Mary E	1864		
3	Branson	Charlotte	1865	Jan. 3, 1830-Aug. 17, 1865	Wife of Hiram
	Van Buskirk	James	1865		
	Reed	James	1865		
	Lee	Mary C.	1865		
2	Barker	Sophia	1866	Mar. 10, 1866	Wife of Isaac. Aged: 44m, 3d
	Conner	Eliza	1867		
2	Barker	Isaac B.	1868	Oct. 7 1868	Sone of Isaac and Sophiah. Aged: 8y, 7m, 7d
	Reed	John W	1868		
	williams	George I.	1868		
	Conner	Daniel	1868		
3	Sneegos	William H.	1869	1869	Aged: 11,
	Reed	Martha J.	1869		
2	Jetmore	Marth Ann	1870	July 21, 1870	Wife of Jacob. Aged: 37y, 7m, 29d
2	Jetmore	Adaline	1870	Aug. 22, 1870	Dau of Jacob and Martha. Aged: 17y

Row	Last Name	First Name	Death Date	Years	Comments
3	Guthrie	John	1870	1870	Infant son of Rush and Patience
	Smith	Laura Bell	1870		
	Jetmore	Adaline	1871		
2	Van Buskirk	Flyod	1872	1865-1872	
	Smith	Mary S.	1872		
1	Slater	Millie	1873	Oc. 6, 1873	Dau of Charles and Rebecca, Aged: 1y, 10m, 25d
	Duckett	John H.	1873		
3	Applegate	Alpherd	1874	Oct. 4, 1874	Son of Louis and M.A. Aged: 8m
5	Anderson	Rhesa	1874	Oct. 23, 1874	Aged: 68y, 4m, 7d
	Tuttle	Sarah G.	1874		
	Audin	Plusa	1874		
2	Jetmore	Jacob	1875	Dec. 25, 1875	Aged: 42y, 5m, 19d
2	Mansur	George S.	1875	Apri. 10, 1875	Aged: 36y, 16d
	Gayman	Jacob	1875		
1	Hobbs	John	1876	Oct. 7, 1876	Aged: 28y, 4m, 17d
	Smith	Winna	1876		
	Conner	Margaret Elma	1876		
	Smith	George M.	1877	Aug. 19, 1877	Son of W.M. and E.T. Aged: 68y, 4m, 7d
	Smith	Larra E.	1877	Jan 23, 1877	Dau of E. and S.E. Aged: 4y, 2m, 12d
	Smith	Edna P.	1877		
	Smith	Sarah E.	1877		
	Smith	Jonathan	1877		
	Applegate	Mary	1877		
	williams	Thomas	1877		
2	Van Buskirk	Oras M.	1879	1878-1879	
1	Hobbs	Benjamin	1880	Dec. 25, 1880	Aged: 63y, 6m, 24d
2	Mansur	Samuel	1881	May 10, 1881	Sone of Geo. S. And A.
	Gibson	Stella M.	1881		
	Justice	Arthur O.	1881		
	Brown	James H.	1884		
	Smith	Amanda	1885	Aug. 8, 1885	Aged: 51y, 9m, 20d
	Justice	Chester A.	1885		
	Modlin	Infant son	1885		
3	Branson	Serieda	1888	Mar. 5, 1888	Wife of Noah C. Aged: 33y, 7m, 21d
	Van Buskirk	Loruhamah	1888		

Row	Last Name	First Name	Death Date	Years	Comments
	Modlin	Susan A.	1889		
	Modlin	Desdamony	1889		
	Brown	Mary E	1891		
	williams	Helen	1892		
6	Gibson	Emery	1894		
	Gibson	Arthur L.	1894		
	Gayman	Mary	1894		
	Richardson	James W.	1898	Mar. 1, 1898	Aged: 82y, 2m, 24d
	Gray	Nancy	1902		
1	Tuttle	Lydia	1903	1871-1903	Mother
	Brown	Jos S.	1905		
1	Tuttle	Wylie Earl	1909	1901-1909	
1	Jetmore	David			Co. B 69 Ind. Inf.
	3 unknown small markers				
2	3 small markers				
2	Mansur	Almeda			Wife of George S. Aged: 18y
3	Open space and 1 stone				
3	Sneegos				Infant dau of Henry and Elizabeth
3	Sneegos				Infant son of Henry and Elizabeth
	2 small stones				
	Small stone				
	Broken stone				
	Stone				
	3 stones				
	2 stones				O
	1 stone				
	Broken Stone				
	Van Buskirk	Francis			
	Van Buskirk	Rebecca			
	Van Buskirk	Child			
	Conner	Borter			